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PLATE A.

Up the Delaware from Child's Arbor, Pa. (Delaware Water Gap).

Up the Delaware from Child's Arbor, Pa. (Delaware Water Gap).

GEOLOGICAL SURVEY OF NEW JERSEY.

JOHN C. SMOCK, STATE GEOLOGIST.

THE PHYSICAL GEOGRAPHY OF NEW JERSEY,

BY

ROLLIN D. SALISBURY.

WITH

APPENDIX

BY

CORNELIUS CLARKSON VERMEULE.

Volume IV. of the Final Report of the State Geologist.

TRENTON, N. J.:
THE JOHN L. MURPHY PUB. CO.,
PRINTERS.
1898.

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To His Excellency George T. Werts, Governor of the State of New Jersey and ex-officio President of the Board of Managers of the Geological Survey of New Jersey:

SIR—I have the honor herewith to submit Volume IV. of the Final Report of the State Geologist. With high respect,

Your obedient servant,

JOHN C. SMOCK,

State Geologist.

TRENTON, N. J., September 26th, 1895.

PREFACE.

The first volume of this series of "Final Report of the State Geologist" was published in 1888. The second volume appeared in two parts, in 1889 and 1890, and the "Report on Water-Supply," Volume III., in 1894. The demand for the first volume, "Topography, Magnetism and Climate," and the exhaustion of the edition, made it necessary either to reprint the volume or to publish a new work, which should include the important statistical matter of that volume. The present work on the physical geography of the State, with an appendix of statistics, is published to meet the demand and fill the gap in the series of reports.

The preparation of the report on the physical geography was put in charge of Prof. Rollin D. Salisbury, whose acquaintance with the State, acquired by his work on the surface geology since 1891, was such as to make the appointment eminently fitting and conducive to a thorough discussion of the subject. The appendix has been prepared by Mr. C. C. Vermeule, formerly in charge of the Topographic Survey and author of the "Report on Water-Supply."

The surface as we see it, with its strata of rock formations in mountain ranges and hills, more or less covered by drift deposits, or in the unconsolidated beds of clays, marls, sands and gravel spread out in valleys and over wide plains, the drainage by the many streams, the lakes among the hills, and the other features of the surface, have been described in the older reports of the Geological Survey, in the nature of the beds or deposits which make up the surface, and their relation as outcrops to extensive formations, characterized by their fossil forms of life or their mineral contents of economic importance. Much has been said in these various publications on the relation of the various strata and deposits to the forms of mountains, hills, tablelands and valleys, and a description in detail of the drainage systems of the State and the geographical distribution of the land and water areas. The references to the geologic structure and its relation to the

shape or configuration of the country have been slight, and there has not been any discussion of the origin of the topography or the development of the surface through the geologic ages.

In the first part of the report the four great natural divisions of the State are described: the Kittatinny mountain and the Kittatinny or Great valley; the Highlands; the red shale and sandstone plain, with its trap ridges; and the clay and greensand marl belt, merging southeast into the coastal plain. The several natural subdivisions, their streams and lakes, and their origin and the distribution of the drift on them, are described in detail. The origin of the sub-valleys of limestone and the slate ridges in the Kittatinny valley; the relations of the rectangular system of the streams in the northern part of the State to the geology; the division of the Highlands into three geographic belts; the level crests of the ranges in the Highlands; the lakes shut in by the drift dams; the streams flowing in the valleys, worn down in the rocks or through gaps across the strata; the changes due to the drift of the glacial age, deposited unevenly on the rocky floor; the sandstones and shales of the Triassic age and their subdivisions, forming the Hunterdon plateau and the low-lying valley of the Raritan; the bold ridges of trap-rock; the coastal plain, including the hill country of the greensand-marl belt, are the topics of the several sections in the first part of the report.

The second part is devoted to the history of the origin and the development of the surface. The changes caused by the elevation of the land out of the sea, and again by its submergence; by the wearing down of the land by rains and streams, carrying the land little by little to the sea; the work of the winds drifting the sands; and the uplifting igneous forces and their results, are the subjects of this part of the work. The history is geological and is long, although the earlier chapters are not given on account of the difficulty of tracing the limits of the older formations as they were laid down, and afterwards more or less covered by later deposits. The history of the crystalline rocks of the Highlands and the land areas of that early time; of the seas in which the limestones, sandstones and slates of Paleozoic time were formed; of the shallow waters of the Triassic age, wherein the shales and sandstones were deposited, and of the land of that age is omitted, because of the obliteration of the older surface forms in the later geographical epochs.

The history begins at the end of the Triassic age, with what is

termed the post-Triassic uplift. Since that time there have been several well-marked stages in the development of the territory of the State, which are summarized in the last section of Part II. The uplifts and the submergences were not of a violent or catastrophic nature, but gradual and the work of centuries, and they affected not only the areas raised out of the sea or submerged beneath the ocean level, but wide stretches of land, and probably were continental in their extent. The uplifted land became at once the ground on which the rains, springs, frost, winds and streams began their work of wearing down—that of *gradation*—and this was continued more or less actively until the whole was worn down to the level of the drainage—base-leveled. As subsidence was in progress material from the adjacent land was carried into these submerged areas, and there were deposits of clays, marls, sands, gravels and boulders made by water and ice. In the first-described of the submergence stages the clays and greensand marls were laid down in the Cretaceous age. In the next one, known as the Miocene, gravels, sands and clays were deposited. In the next later, termed the Pensauken epoch, there appear to have been deposits made by ice as well as water, marking probably the first invasion of glacial ice. The last submergence has been called the Cape May epoch, on account of the formation of that peninsula in that epoch. The uplifts between these subsidences were equally marked in their effect upon the surface, as the streams were then active. In one of them, known as the glacial, a continental ice-sheet covered the northern part of the State, and left its mark on the surface in the morainic hills of drift from Perth Amboy to Belvidere. It was probably the second ice invasion. The glacial epoch was followed by the subsidence of the Cape May epoch, which is the last well-marked stage in the history.

The changes in the shape of the land and the seas, and in the streams and their courses have been many in these geological epochs, and of great extent. Southern New Jersey has been at times a belt of islands separate from the northern mainland. The rivers have had various courses, notably the Raritan and the Delaware. The great Lake Passaic and other large sheets of water have had their stages of growth and disappearance.

All this history of later geological time with its changes of land and water are given in detail with illustrations, showing the State at given epochs, and its shore-lines and river systems. It is interesting

as the work of natural forces shaping the State for the coming of man, and is the prelude to the historic period.

The relief map of the State which accompanies this report was prepared by Mr. Vermeule. It is based upon the topographical survey, and is, therefore, an accurate *picture* of the surface relief. The great features of the State, its ranges of mountains, hills, table-lands, plains, marsh-lands, and streams and water areas, are all shown in their proper relations to one another, and make a comprehensive illustration of the topography as described in the text of the Report, supplemented by many statistics in the Appendix. A leading object in the publication of the map has been to put it in every school-house in the State as an aid in the study of geography. Its general use also must tend to make all who study it familiar with the large and more prominent features of the State, and to stimulate inquiry into the origin of those forms, leading to educational results of value. It conveys information graphically, which can be grasped readily and is retained with ease. The original drawings were made under Mr. Vermeule's immediate supervision. The painstaking care and attention given to the work by the engravers, Messrs. Julius Bien & Company, have contributed to the success of the map.

The pictorial plates of the volume are reproduced from photographs and show several of the characteristic features, as the Palisades, the Delaware Water Gap, the gap in the Green Pond-Copperas mountain range, the Kittatinny valley and mountain, the Highlands, and the dunes of the ocean shore.

The several profiles exhibit graphically the contour of the surface as compared with that before the erosion of the valleys had begun, and indicate how the old land level was carved out by the streams, and made into valleys and ranges of hills. The illustrations make clear the text and attract the reader.

The Appendix has been prepared by Mr. C. C. Vermeule. It contains all the important tables of statistical matter of the volume on "Topography, Magnetism and Climate," excepting the article on climate, which has been omitted as not pertinent to this discussion of the physical geography of the State. The Table of Geographical Positions, with the introduction thereto, and the description of the bench-marks of the topographic survey of the State, have been reprinted. The list of elevations of prominent points also is reprinted with slight revision. The notes on the elevation of the topographical

features have been added (pages 101–106). The heights of the mountains, hills, valleys and plains above the sea level, and their average elevation, are given in these notes, as also the elevations along the river-courses. They serve to explain the relations of the more characteristic surface features to the ocean, illustrated by the relief map.

The table of drainage areas, forested areas and population of the stream basins is reprinted, with the addition of the statistics of the natural yield of the large streams in millions gallons daily, an important practical element in the study of the surface and of the flow of streams. The subject has been discussed in detail in the report on water-supply. A tide table has been added to show the range or rise and fall of the tides, and also the relative time of high water at important tide stations. The areas of the several political divisions are given as they were at the date of this report. The population tables have been made to include the results of the State census of 1895, and the distribution according to the divisions at the time of that census.

The figures of the Magnetic Survey have been revised slightly. A map illustrates the table of magnetic declinations.

On account of the many important tables in the appendix, and the difficulties attending the preparation of the maps, and, in particular, the relief map of the State, the publication of this volume has been delayed a long time. The necessity of accurate statistical matter and the value of the diagrams, sections and maps which illustrate so graphically the geological history of the State are, however, such as to justify the delay in the issue of the work.

JOHN C. SMOCK,
State Geologist.

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PART II.—THE HISTORY OF THE TOPOGRAPHY.

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PLATES.

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THE PHYSICAL GEOGRAPHY OF NEW JERSEY.

PART I.

THE TOPOGRAPHY.

PART II.

THE HISTORY OF THE TOPOGRAPHY.

PART I.

THE TOPOGRAPHY OF NEW JERSEY.

SECTION I.

GENERAL STATEMENT.

The Atlantic slope of the United States is a fairly distinct geographical province. Its eastern boundary is the sea; its western boundary on the north is the divide between the drainage flowing southeast to the sea, and that flowing northwest to the St. Lawrence. Farther south, its western limit is the divide between the streams flowing east to the Atlantic, and those flowing west to the Ohio and Mississippi rivers. The great Appalachian system of mountains belongs partly to the Atlantic slope and partly to the geographic province next west, the line between them being the water-shed, or water-parting, between the drainage which flows to the east and that which flows to the west. This line does not everywhere correspond with the highest part of the mountain system, and is therefore in some sense arbitrary, as most lines separating geographical provinces are. The whole of the State of New Jersey lies within the province of the Atlantic slope.

On the basis of altitude, the Atlantic slope is divisible into several sub-provinces,* all of which are elongate in a direction roughly parallel to the shore. 1°. Next the coast, there is usually a belt of low land, few or many miles in width, known as the *Coastal plain.* 2°. Inland from the Coastal plain, there is a zone intermediate in height, between the Coastal plain to the east and the mountains to the west. In the South, this is known as the *Piedmont plateau.* 3°. The

*McGee. Seventh Annual Report U. S. G. S., p. 548.

mountainous part of the slope constitutes the third sub-province, known as the *Appalachian zone.*

The Atlantic slope may be divided into two sections—a northern and a southern—in which the Coastal plain is narrow (or absent) and wide, respectively. It is in New Jersey that these two sections meet, and the division line, as nearly as a line may be drawn, runs from the Raritan river, just below New Brunswick, on the northeast, to Trenton, on the southwest. South of this line, the Coastal plain expands, and all considerable elevations recede correspondingly from the shore. According to this division, the extreme northern portion of the State belongs to the northern section of the Atlantic slope, while the southern portion belongs to the southern section.

It is in the southern section of the Atlantic slope that the three sub-provinces mentioned above are especially well shown. In the northern section, they are less well developed, and, even where the topography is comparable, the underlying rock structure is different.

In general, the Coastal plain of the middle and southern Atlantic slope is made up of horizontal or but slightly inclined strata of unindurated or semi-indurated material, the slight dip of which is toward the coast. They are of Cretaceous,* Tertiary and Pleistocene age. The Piedmont plateau, where most typically developed, is made up chiefly of crystalline schists of great age. They have generally been referred to the Archean, but this reference is now looked upon with more or less doubt. Strata of Triassic age occur at various points within this plateau, from Pennsylvania on the north to South Carolina on the south. The mountain zone is made up chiefly of folded Paleozoic strata, though the western margin of the crystalline schists often attains mountainous heights.

North of New Jersey the Coastal plain has little development, though Long Island and some small areas farther east and northeast are to be looked upon as parts of it. The area which corresponds geologically to the Piedmont plateau of the South is represented in New Jersey and New York by the Highlands, while the Kittatinny mountain and Kittatinny valley of New Jersey and their continuations in New York and Pennsylvania correspond with the outer portion of the mountain or Appalachian zone of the region farther south.

In the southern part of the Atlantic slope, the Coastal plain and

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*Marsh thinks some of them Jurassic. See Am. Jour. Sci., 4th Series, Vol. 2, p. 433, 1896.

the Piedmont plateau meet along what is known as the *Fall line*, the name being derived from the fact that most of the streams, in crossing this line, have falls or rapids. The Fall line marks the head of navigation on many of the streams, and has determined, or helped to determine, the location of many of the larger cities of the Coastal plain south of New York. But while the Coastal plain abuts against the Piedmont plateau south of New Jersey, there is in this State, an intermediate belt between the Coastal plain on the one hand and the Highlands (corresponding to the Piedmont plateau) on the other. This is the belt of Triassic rock which, throughout most of the southern section of the Atlantic slope, has no correlative in corresponding position. In North Carolina only a belt of similar rock intervenes between the crystalline schists and the Coastal plain.

Were New Jersey to serve as the standard area, the Atlantic slope should be divided into four zones instead of three. These would be, commencing inland: 1°, the Appalachian zone of folded strata (the Kittatinny valley and mountain); 2°, the Highlands area (the area of crystalline schists); 3°, the Piedmont plain (the Triassic area); and, 4°, the Coastal plain (the area of the Cretaceous and younger strata). These four divisions are outlined on Plate I., page 6. While these divisions, stated in these terms, seem to be based on geology, they are nevertheless topographic as well; nor is this correspondence fortuitous, for topography and geology are closely related, and the latter often finds its explanation in the former.

The Appalachian zone, so far as represented in New Jersey, has a relief of more than 1,500 feet, its highest point being more than 1,800 feet above the sea. Its topography may be said to be characterized by steep-sided, even-crested, asymmetrical ridges, alternating with capacious valleys parallel to them. The same characteristics affect most of the province throughout the Atlantic slope, so that the Kittatinny mountain and the associated valley of the same name may fairly stand as the type of topography affecting this zone. The rocks are stratified and highly inclined; the outcrops of the hard layers constitute the ridges, while the valleys mark the outcrops of the softer layers. Geologically, this sub-province is sharply differentiated from the next. Topographically, the distinctness is less perfect.

The second zone, known in New Jersey as the Highlands, has a relief of about 1,200 feet, its highest points rising to elevations of more than 1,400 feet. It is made up of a series of semi-isolated

block-like or plateau-like masses, those near one another approaching a common elevation. They are sometimes small in area, but never assume the character of peaks. The elevations and depressions have a less constant direction than in the Appalachian zone, and the rocks are largely devoid of distinct bedding. The topography of the Highlands is representative of the topography of the Piedmont plateau outside the State. Topographically, no line can be drawn which definitely separates this province from that next east; yet the transition from the one to the other is in a narrow belt, centering along the eastern edge of the crystalline schists. The line marking the eastern limit of their outcrop is, therefore, taken as the boundary line of this province.

The third zone of New Jersey, the Piedmont plain, lying south and east of the Highlands, has a relief of more than 800 feet, and its lowest part reaches sea-level. Its topography is more heterogeneous than that of the preceding zones. It is characterized in part by a gently undulating surface, as in the vicinity of New Brunswick; in part by bold asymmetrical ridges, such as the Watchung mountains and the Palisade ridge; and in part by low, abrupt-sided plateaus, the Hunterdon plateau about Quakertown, and the Sourland mountain plateau, being good examples. The relief is less than in either of the preceding zones, but the ridges are as abrupt as in the first, and more so than in the second. The ridges have a general northeast-southwest trend, but there is no close correspondence between their direction and the direction of the main drainage lines, as the Raritan and Passaic rivers show. The rock is chiefly stratified, the layers are considerably inclined, and the outcropping sheets of trap, or other hard layers of rock, constitute the ridges. Since this zone of New Jersey has little continuation to the south, its characteristic topography has little development in that direction, though it extends somewhat beyond the Delaware.* But to the northeast, in southern New England, the features characterizing the Piedmont plain of New Jersey re-appear.

In the fourth topographic province, the Coastal plain, both the relief and the average elevation, are less than in the preceding zones. Its highest point in New Jersey does not reach an altitude of 400 feet, and since it descends to sea level about the borders of the State,

*The Triassic rocks continue far to the south, but not in the same geographic relations.

the figure representing the greatest altitude also stands for the total relief. The larger part of the Coastal plain as it occurs in New Jersey may be looked upon as a plain—highest toward its middle, and lowest about its margins, the surface of which has been trenched by the streams which flow over it. Within the province, as a whole, the elevations and depressions have no prevailing direction. While abrupt ridges, comparable to those of the more northerly portions of the State, are absent, there are steep, isolated hills, like Mount Holly, Arney's mount, the Mount Pleasant hills, and the Navesink highlands, which, though of no great height, are yet striking topographic features. The formations are chiefly of unindurated material—sands, clays, marl, etc.—and the beds dip at a low angle to the southeast. Topographically, the Coastal plain is less distinct from the Piedmont plain than the Piedmont plain is from the Highlands, or than the Highlands from the Appalachian zone. The line separating the two zones would best be drawn, when it is necessary to draw it at all, along the *Fall line* already defined. More than half the State belongs to this zone, which has its greatest development farther south, and but slight representation to the north.

These four divisions are sharply distinct from the standpoint of geology, and, likewise, in their type development, from the standpoint of geography. Yet sharp lines separating one topographic sub-province from another cannot everywhere be drawn without doing violence to the facts. This is especially true of the third and fourth divisions referred to above. Furthermore, there is some basis in topography for a further subdivision of the provinces outlined above, and these minor subdivisions would, in some cases, be as distinct from one another as the larger divisions.

SECTION II.

THE NORTHWESTERN PORTION OF THE STATE.

The area here referred to is bounded on the east and south by a line running from Suffern, N. Y., through Pompton, Boonton, Morristown, Bernardsville and High Bridge to the Delaware river below Riegelsville. It embraces the area of crystalline schists and all the stratified rocks associated with them inside their southeastern limit. It is divisible into two zones, the one—the Appalachian—including the Kittatinny mountain and valley, and the other the Highlands. These two zones are measurably distinct, both topographically and geologically, yet in spite of their differences, they have some features in common. Both have great relief, both are mountainous, both are alike in having neighboring summits of approximately equal height, and both are without sharp peaks. They are unlike in the details, and to some extent even in the broader features of their topography. In the one zone, the Appalachian, the ridge and valley type of topography prevails; in the other, the Highlands, the elevations are more massive and there is less correspondence in direction between them and the associated depressions.

The two topographic zones correspond with two sets of formations, the one stratified, the other mainly unstratified, or but indistinctly bedded. The stratified rocks, for the most part, lie to the northwest, and embrace most of Sussex county and a part of Warren. They cover the areas known as Kittatinny valley, Kittatinny mountain, and the area between this range and the Delaware river, and constitute the Appalachian zone. The unstratified rocks (crystalline schists) correspond in area with the Highlands, but within this area there are narrow bands of stratified rock, notably in the Green Pond mountain belt.

I. THE APPALACHIAN ZONE.

The topography of this zone is notable for the fact that all considerable elevations are long and narrow, and extended in a general northeast-southwest direction. The depressions which lie on either side of the elevations are trough-like valleys, and parallel to the

ridges which limit them. These facts find their explanation in the bedding of the rock, the strike of which is in the direction of the ridges and valleys. The rocks are of unequal hardness, and it is the outcropping edges of the hard layers which constitute the ridges, while the depressions mark the sites of the outcrops of the less resistant beds. Thus, the Kittatinny mountain represents the edge of a hard stratum of conglomerate, while the Kittatinny valley is underlain by rock of a much less obdurate sort.

The Kittatinny mountain.—One of the most striking topographic features of northwestern New Jersey, is the Kittatinny mountain, extending, within the limits of the State, from the Delaware Water Gap on the southwest to the New York line on the northeast, a distance of about thirty-six miles (see accompanying relief map). The

Fig. 1.

Section through Kittatinny mountain, two and five-eighths miles north of Culver's gap. Vertical scale, X 5.

range is continued in both directions beyond the limits of the State. The general direction of the range in New Jersey is from a little east of northeast to a little west of southwest, but near the New York line it changes to S. 15° W. In width, the range varies from two miles or less in its southern portion to four or five miles near its northern end, again becoming narrower just south of the State line. Throughout a part of its course, the range is double-crested, and the eastern crest, where two exist, is usually somewbat higher than the western.

The two slopes of the mountain are notably unequal, as shown in Figs. 1 and 2, which represent cross-sections of the mountain a little north of Culver's pond, and three miles above the Delaware Water Gap, respectively. The east slope is steep, in places almost precipi-

tous. The west slope is less abrupt, though even here the angle is often high. This is especially true below the Wallpack bend of the Delaware. The inequality of slope finds its explanation in the dip of the rock, which is to the northwest.

The lower limit of the mountain on its eastern side is 900 to 1,000 feet above the level of the sea, and has a nearly constant altitude. Above this level, the crest of the ridge rises by a slope so steep as to make ascent difficult, and in many places impossible, to a height which, on an average, is about 1,600 feet above the sea, giving the crest of the range an average elevation of about 600 feet above its eastern base. Its highest point, between one and two miles south of the State line, has an elevation of a little more than 1,800 feet.

To the north, where the range is wide, its western slope is less

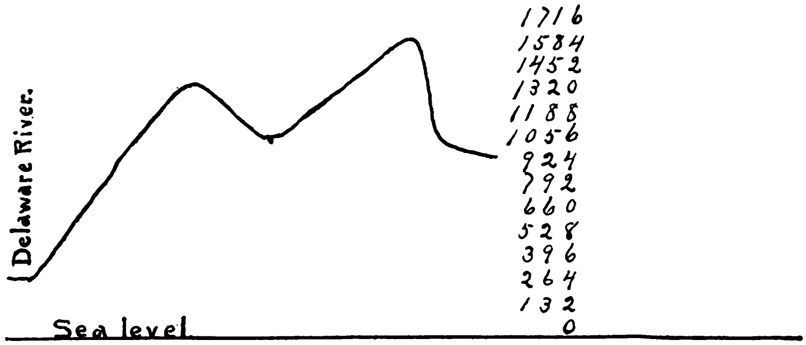

Fig. 2.

Section through Kittatinny mountain, three miles north of the Delaware Water Gap, showing the double crest. Vertical scale, X 5.

clearly defined than to the south, where it is narrow. From the eastern crest of the wider part of the range, the westward descent is but slight to a broad, rolling plateau, three to five miles wide, the upper levels of which reach an elevation of more than 1,200 feet.

In the range there are occasional gaps, the most notable being that through which the Delaware flows and known as the Delaware Water Gap. Where this stream crosses the mountain it is but 287 feet above tide. The mountain to the east rises to a height of nearly 1,500 feet, giving an almost precipitous slope of about 1,200 feet. The next most important break in the range is Culver's gap, four miles northwest of Branchville. This is a wind gap—that is, a gap through which no stream flows. The bottom of this gap is 915 feet

Delaware Water Gap and Kittatinny mountain from Manunka Chunk. The even crest of the Kittatinny range, in the background, represents a remnant of the Kittatinny base-level (p. 88) The upland in front of the range, best seen to the left, represents the plain developed in the subsequent incomplete erosion cycle (p. 94), while the lowland in the center was developed in a still later cycle.

plateau, often two miles in width. Just south of the State line, however, the plateau again narrows into a ridge, much as to the south. The height of this western ridge varies from about 650 feet to 900 feet, and its crest is relatively more irregular than that of the main range to the east. It attains its greatest average elevation where it is widest, and it is most irregular and lowest where it is narrow.

The valley which separates this ridge from the Kittatinny range has an elevation of something more than 300 feet at Flatbrookville, 440 feet near Peters Valley, and about 600 feet at Hainesville. The valley of Mill Brook, which is really the northerly continuation of the Flat Brook valley, has an elevation of between 500 and 600 feet. The western ridge, known as Wallpack ridge to the south, and as Hog-back ridge to the north, is therefore set off from the Kittatinny range by a valley 200 to 400 feet deep.

West of the crest of this western range flows the Delaware, separated from it at many points by considerable areas of lower land, usually composed of glacial drift. This part of the valley in which the Delaware flows is really a part of the extensive valley depression which extends from Kingston, N. Y., southwest into Pennsylvania.

The geological relations of the Kittatinny range, and of the country to the west of it, are significant. While the crest of the main range represents the line of outcrop of the hard Oneida conglomerate, one of the most resistant formations of northern New Jersey, its west slope is made up of the less-resistant Medina sandstone and shale. The Wallpack and Hog-back ridges, lying west of the Kittatinny range, represent the outcrop of the moderately-resistant Oriskany and Cauda Galli formations, and the valley which separates this ridge from the Kittatinny mountain, is underlain by limestone, the least obdurate formation in the northwestern part of the State. It is doubtless because of the limestone that the valley has been opened out between the Kittatinny range and the subordinate ridge to the west.

The lowland west of the secondary ridge, and between it and the Delaware, is likewise underlain by limestone. Thus, it is seen that the physical features of this part of the State are intimately connected with its geological structure.

The Kittatinny valley.—Immediately east of the high Kittatinny range lies the broad, trough-like Kittatinny valley, the axis of which

is parallel to the mountain range which forms its western margin (see Figs. 1 and 2, Plate II., p. 16, and relief map). Its eastern border is formed by the western border of the Highlands, and may be said to run from New Milford, N. Y., to Franklin Furnace, and thence by a somewhat crooked line south to Andover and Alamuche, and thence along the Pequest river to Belvidere. Stated in other terms, the eastern boundary of the valley is formed by the following mountains, which are nothing more than partially distinct sections of the Highlands: Wawayanda, Hamburg, Pimple hills, Sparta, Alamuche, Pohatcong and Scott's. These mountains vary in height from 1,000 to 1,400 feet. The length of that part of the valley which lies in New Jersey is about forty miles, and its width is from ten to thirteen. The western border of the Kittatinny valley is distinct on the accompanying relief map, but the eastern border is less clearly defined.

The altitude of the western margin of the Kittatinny valley, where it abuts against the base of the Kittatinny mountain, is from 900 to 1,000 feet, and about 600 feet below the crest of the range. The altitude of the eastern margin of the valley is 400 to 600 feet, and likewise about 600 feet below the crest of the uplands forming its eastern margin. The definition of the valley on the east is much less sharp than on the west.

Within the Kittatinny valley thus outlined, there are two notable elevations. These are the Pochuck mountain in its northern portion, 1,100 to 1,200 feet high, and the Jenny Jump and Mohepinoke mountains on the south, something more than 1,100 feet high. The great Kittatinny valley, therefore, is a broad depression, about 600 feet below its lateral boundaries, with a notable massive elevation in either end. The relations of the valley to the mountain on the west and the Highlands on the east are shown in Figs. 1 and 2, Plate II., p. 16.

Even apart from the Pochuck, Jenny Jump and Mohepinoke mountains, the bottom of the valley is by no means flat. It does not correspond to the conventional idea of a river valley, and, indeed, it is not a river valley in the simple sense of the term. Through it flow several streams, separated by divides, which, though they seem low in this mountainous region, are yet much higher than the divides between streams in some other parts of the State. Within the main Kittatinny valley there are two principal sub-valleys, parallel with each other,

and with the axis of the main depression. Tributaries to these sub-valleys have been developed to such an extent that the floor of the great trough has been thoroughly dissected into a series of hills and valleys, and has a notably undulating topography. The sub-valleys in the bottom of the great valley lie 200 to 300 feet below the divides which separate them, and the divides have an altitude ranging from 700 to 900 feet.

The westernmost of the two principal sub-valleys is occupied by the Paulins kill, flowing southwest, and the Papakating creek, and the lower part of Wallkill river, flowing northeast. The highest point in this sub-valley is not far from Branchville, at the divide between the Paulins kill and the Papakating creek, and is 501 feet above sea-level. This sub-valley lies along the northwestern side of the great valley, while the other lies nearer its eastern limit, and is occupied by the Pequest river in its southern portion and by the Wallkill river and Pochuck creek in its northern. The Lehigh and Hudson River railway occupies this sub-valley throughout its course from the New York line to Belvidere. Its highest point, 600 feet above the sea, is at Mulford Station.

In some parts of the Kittatinny valley, especially to the south, these two sub-valleys are not notably distinct, while to the north, between Franklin Furnace and Deckertown, the Wallkill crosses from the one to the other. The hills and ridges separating these sub-valleys are mostly of slate or shale, and almost everywhere show a disposition to arrange themselves in lines, the trend of which corresponds with that of the mountain range to the northwest. This trend is sometimes lost, especially in the southern part of the Kittatinny valley.

The dependence of topography upon rock structure is hardly less distinct in the Kittatinny valley than in the region to the west. The sub-valleys in the great valley are, for the most part, on limestone. This is true of the valley of the Paulins kill in the western sub-valley, and of the Pequest-Pochuck system on the eastern side. It is over an area of limestone, too, that the Wallkill crosses from the eastern to the western sub-valley. The limestone is a less resistant rock than the shale, and the position of the sub-valleys on the former, and of the divides on the latter, appears to have been determined by this fact.

PLATE II.

EXPLANATION OF PLATE II.

Fig. 1.

Profile from Milford, on the Delaware, to the Hudson, along a line essentially parallel to the north line of the State, showing the relation of the mountain crests and valleys. The dotted line represents the approximate surface of the Kittatinny base-level, or Schooley peneplain. Lm = limestone. The oblique lines do not indicate structure.

Fig. 2.

Profile from the Delaware, in latitude 41° 9′, to New York bay, showing the geological structure (Cook) of the north part of the State, in addition to the topography. The dotted line represents the approximate surface of the Kittatinny base-level, or Schooley peneplain. Lm = limestone; S = shale; Cg = conglomerate.

Fig. 3.

Profile from Shawnee island, in the Delaware river, to Staten Island, showing the same features as Fig. 1, along this line. The oblique lines do not indicate structure.

Fig. 4.

Profile from near Phillipsburgh, on the Delaware, to Sea Girt, on the Atlantic coast. The abbreviations and the dotted lines have the same meaning as above.

II. THE HIGHLANDS.

The Highlands of New Jersey, as that term is commonly used, embraces the area covered by the crystalline schists east and south of the Kittatinny valley (see Figs. 1 and 2, Plate II.) It is the southward continuation of the Highlands of New York. The Highlands is about eighteen miles wide at the northern line of the State, and Greenwood lake, half of which lies in New York and half in New Jersey, is about midway between its eastern and western limits. The eastern portion of the Highlands terminates about forty miles from the State line, in the vicinity of Morristown, Bernardsville and Peapack, while the western portion extends to the Delaware at Riegelsville. The southwestern extension of the Highlands is much broken, but Scott's mountain and Marble mountain, northeast of Phillipsburg, and Musconetcong mountain, near Riegelsville, may be looked upon as its termini so far as New Jersey is concerned. As a whole, the area has a northeast-southwest trend, essentially parallel to the Kittatinny valley and mountain.

The Highlands is an area of high land notably above its surroundings on all sides. Generally speaking, it is highest to the northwest and lowest to the southeast; but instead of being a plateau, as its name might suggest, it is an area of strong relief. The valleys of the Pequannock, the Wanaque, the Rockaway, the Musconetcong and the South Branch of the Raritan, as well as the valleys of many lesser streams, are notably below the summit level of the region in which they occur. So numerous are the valleys, large and small, and so far do they separate different portions of the Highlands from one another, that the various parts have received distinct names. Thus we find on the western side of the Highlands the names Wawayanda mountain, Hamburgh mountain, Sparta mountain, Alamuche mountain, the Upper and Lower Pohatcong mountains and Scott's mountain. The Jenny Jump, Mohepinoke and Pochuck mountains lie west of the body of the Highlands, though they are but isolated portions of it. In the central portion of the great Highlands area, there is another series of names locally applied to various more or less distinct ranges. Here are found, commencing at the north, Bearfort mountain, Kanouse mountain, Copperas mountain, Green Pond mountain, Bowling Green mountain, Schooley's mountain and Musconetcong mountain. The eastern portion of the Highlands is less high, and

local names have been less commonly applied to the more or less isolated elevations; but that portion between the Wanaque and Ramapo rivers is known as Ramapo mountain, and farther south are found Trowbridge mountain, Mine mountain, etc. Most of the mountains enumerated above, unlike the Kittatinny range and the Wallpack ridge, are not narrow, even-crested ridges, but mountain masses instead, often with horizontal dimensions approximately equal in all directions. It follows that the northeast-southwest trend, so pronounced in the topography of the region farther west, is much less conspicuous in the Highlands. There are various local features, however, some of them obtrusive, which show the recurrence of this trend. This is especially true of the Green Pond mountain and associated ranges, and of the valleys and ridges in Warren county.

The crests of adjacent mountains in the Highlands, so closely approximate one another in elevation that, were the intervening valleys to be filled (see Figs. 1 and 2, Plate II.), the Highlands would be converted into a plateau, declining gently to the south and east. Its surface, even where highest, would be somewhat below the crest of the Kittatinny mountain, but if the plateau surface of the Highlands, restored by filling the valleys, were projected northwest to the Kittatinny mountain, it would reach its crest (see dotted lines, Figs. 1 and 2, Plate II.) If, then, the Kittatinny valley, as well as the valleys which trench the Highlands, were filled, northern New Jersey, from the Kittatinny mountain to the eastern border of the Highlands, would be a plateau, possessed of some undulations, and sloping gently to the southeast.

Subdivisions of the Highlands.—While the Highlands area is in some sense a unit, it is nevertheless so diversified that it is convenient to refer to different portions separately. On the whole, the division suggested many years since by Mr. Vermeule* is the most rational. This division recognized several northeast-southwest belts, separated, or partially separated, from one another by more or less considerable valleys. The westernmost of these belts was called by Mr. Vermeule the Alamuche-Pohatcong range. As originally defined, it begins on the north at Franklin Furnace, and extends southwest, with more or less interruption, to the Delaware river, and includes the Pimple hills, Alamuche mountain, the Upper and Lower Pohatcong mountains, Scott's and Marble mountains. Closely associated with Scott's

*Geological Survey of N. J., Vol. I., 1888.

mountain are the Jenny Jump and Mohepinoke mountains. With this series of elevations Pochuck mountain should be associated. The name Alamuche-Pohatcong would then cease to be definitive, and on the basis of naming adopted by Vermeule the name should be the Pochuck-Alamuche-Pohatcong range. Since this name is cumbersome, it is suggested that the range be called the Western Highlands range.

The geographic basis for the separation of this part of the Highlands from that which lies to the east, is found in the partial isolation effected by the broad, capacious valleys which intervene between them. At the south, it is the valley of the Musconetcong, separating the Pohatcong and Alamuche mountains on the west from the Musconetcong and Schooley's mountains on the east, which marks the eastern limit of the range. Farther north, the upper portion of the same valley, occupied by Lubber's run, separates Alamuche mountain on the west from the main Highlands range on the east. At the head of this valley, the separation of the western range from that next east is incomplete, but farther north, the valley occupied by the Upper Wallkill, as far north as Franklin Furnace, and by Pochuck creek still farther north, separates the Pimple hills on the west from Sparta mountain on the east.

Proceeding eastward, the second division of the Highlands includes the area between the valley just mentioned, and that extending from Greenwood lake on the northeast to High Bridge on the southwest. It includes the heart of the Highlands, and will be here referred to as the Central Highlands range.

The third division of the Highlands has been called the Passaic range. As heretofore defined, it is bounded on the west by the Greenwood lake-High Bridge valley, and on the east by the valley of the Wanaque river, which sets off the small area of the highland, known as Ramapo mountain. Considering New Jersey alone, there would seem less reason for the separation of the Ramapo mountain (the south end of the Hudson range of Vermeule) from the range next west, than for the separation of the other three ranges from one another. Followed northward into New York, the reason for the separation is more apparent.

The Western Highlands or Pochuck-Alamuche-Pohatcong range.— This range should really be looked upon as commencing, not with the Pimple hills at Franklin Furnace, but with the Pochuck mountain farther north. This mountain is in line with the southern part

of the range, although separated from it by a depression several miles broad. Pochuck mountain is virtually surrounded by the valleys of two streams—the Wallkill river and the Pochuck creek (see relief map). These streams join a short distance north of the State line, and their valleys cut off the mountain in this direction, while the divide between the headwaters of the Pochuck and the Wallkill, near Hamburgh, is so low as to cut off the mountain to the south. The broad depression separating Pochuck mountain from the main part of the range to the southwest, may be looked upon as an eastward extension of the Kittatinny valley, between Hamburgh and Franklin Furnace. The highest crest of Pochuck mountain rises to an elevation of something more than 1,100 feet, though its average height is considerably less.

South of Franklin Furnace, the continuation of the range is begun with Pimple hills, which have a maximum elevation of something more than 1,100 feet. Southwest of the Pimple hills the range is broken by a pass, through which the N. Y., S. & W. R. R. passes. South of this point, elevations of more than 1,100 feet are soon reached. West of Lake Hopatcong, the highest crests are more than 1,200 feet above sea-level, and still farther to the southwest, near Alamuche, the range reaches its greatest elevation—1,248 feet. Southwest of Hackettstown, the range is divided by the Pohatcong valley into a northwest portion, Scott's mountain, and a southeast portion, the Upper and Lower Pohatcong mountains. The former reaches an elevation of something more than 1,200 feet. The latter is lower, the Upper mountain reaching elevations of 1,000 to 1,100 feet, while the Lower mountain fails by 100 or 200 feet to reach even these heights.

The surface of the Alamuche-Pohatcong range is notably irregular. Nowhere are there extensive flats at high levels, and nowhere are there uninterrupted crest-lines of great length. The high elevations are more or less isolated, and constitute a succession of partially-separated mountain masses, or short ridges, rather than a continuous range like the Kittatinny mountain. Irregular as the surface of the range seems, there is yet an element of regularity, in that the crests, especially those near one another, have an essentially constant elevation.

The Musconetcong and the Sparta-Vernon valleys.—The valleys which separate the Western Highlands range from the range next east

(see Figs. 1 and 2, Plate II., p. 16) do not constitute a continuous depression. The heads of the Sparta valley on the north, and the Musconetcong on the south, fail to reach each other, being separated by a high, though narrow, ridge, which connects this range with that next east (see relief map). It is a notable fact that the Sparta valley is co-extensive with the narrow belt of less-resistant rock (limestone) which projects into the highland area, southwest of Franklin Furnace, and that the Musconetcong valley is likewise co-extensive with a belt of limestone and shale which projects northeastward into the Highland area from the southwest (see geological map). The limestone areas, which seem to have determined the position of these valleys, fail to reach each other by seven or eight miles, and it is within this stretch that a separating valley fails. The Sparta valley is really continuous with the Vernon valley east of the Pochuck mountain, although the Wallkill does not follow this course. The continuity of these valleys is one of the reasons for regarding the Pochuck mountain a part of the westernmost range of the Highlands.

The depth of the valley is inconstant, but throughout most of its course it is not less than 400 to 500 feet below the adjoining mountains, and often more. The separation of the Western Highlands range from that next east, is therefore well marked, as the relief map shows.

The Central Highlands range.—The range of the Highlands next southeast may be called the Central Highlands range or plateau.* That part which lies within New Jersey is bounded on the west by the Vernon, Sparta (see Figs. 1, 2 and 3, Plate II.), and Musconetcong valleys, and on the east by the Greenwood lake-High Bridge valley. Its northern end is but a few miles north of the State line (see relief map), and from this point it stretches southwestward to the Musconetcong mountain and the Delaware river. This range is unlike that to the west, in that it is much broader throughout most of its course, and in that it is much less dissected by valleys. Locally it is so broad as to merit the name of a plateau. Between the State line and Lake Hopatcong, it has a width varying from four to seven miles, but southwest of that lake it narrows, and finally ends at the Delaware in a ridge but two miles wide. That part of the range which lies north of the State line is narrower than the broader part of the range in the State, and fronts the Kittatinny valley on the west.

* The Central Highlands plateau of Vermeule. Loc. cit, p. 143.

The elevation of the range in New Jersey varies from nearly 1,500 feet at the north to something like 800 feet at the southwest. Its northern end is higher than that of the Alamuche-Pohatcong range by about 300 feet, but the southwest ends of the two ranges are of about equal height. The Central Highlands range, therefore, has a notable decline to the southwest, while the crest of the Western range has about the same height throughout its course.

The Central Highlands range is much less broken than the Western range. It is interrupted by notable passes but twice, once between Oak Ridge and Franklin Furnace, and once between Port Oram and Waterloo.

The range has its most plateau-like character north of the first of these passes, where its average altitude is about the same as that of the crests of the Western range, between 1,100 and 1,200 feet. The highest peaks are between 300 and 400 feet above the general plateau level. The range maintains its height south of Stockholm, where its summits attain an elevation of more than 1,300 feet. Farther south, the general level of the plateau is interrupted by the depression in which Lake Hopatcong lies. South of this lake, the plateau-like character is resumed in the Schooley mountain, much of which rises to an elevation of more than 1,100 feet, and the highest point of which is more than 1,200 feet above tide.

Schooley's mountain is opposite the Alamuche and Upper Pohatcong mountains of the Western range, and it is to be noted that its elevation is about the same as that of those mountains. It should be further noted that the plateau-like Schooley's mountain has approximately the same elevation as the northern part of the range where the plateau-like character is developed. It thus appears that the crests of the Western range, and the plateau portions of the Central range, as far south as Washington, have about the same elevation.

Southwest of Schooley's mountain the elevation of the Central range declines, and at few points between Schooley's mountain and the Delaware river are elevations of 1,000 feet reached. As the Central range declines to the southwest, it becomes more dissected, thus simulating more closely the general character of the Western range. It is only in the southwestern extensions of the Western and Central ranges that the former becomes the wider, and it is here only that it assumes, in Scott's mountain, a plateau-like character. Where the Western range broadens so as to exceed the Central range in width, it also exceeds it in height. Thus the broad Scott's mountain of the

Western range is higher than the narrower Musconetcong of the Central range, but it has the same or essentially the same altitude as Schooley's mountain, of comparable width.

The Greenwood lake-High Bridge valley.—The depression which bounds the Central Highlands range on the east is clearly shown on the relief map (see, also, profiles, Plate II., p. 16) and is one of the most remarkable valleys in the State. It is remarkable for its continuity, in the absence of a continuous stream. To the north, the drainage of the valley is into Greenwood lake, and thence to the Wanaque river. The second section of the valley drains southwest to the Pequannock, which cuts through the Highlands from northwest to southeast, and crosses this broad valley instead of following it. A dam twenty-five feet high across the Pequannock a mile above Oak Ridge would send the waters of this stream over the low divide which separates it from the Rockaway.* So easily might the course of a considerable stream be changed. South of the Pequannock, and up to within a fraction of a mile of the stream itself, the drainage of the valley is to the southwest, and presently becomes the Rockaway river. This stream follows the valley to the southwest to the terminal moraine near Port Oram, but, instead of following it farther, it here turns abruptly, and, following the example of the Pequannock, cuts through the Highlands to the east. South of the abrupt turn of the Rockaway, there is little drainage along the valley to this stream. From the moraine the drainage is all to the southwest, via the South Branch of the Raritan, through the broad German valley to High Bridge. Between High Bridge and Greenwood lake, the valley is therefore occupied by four different lines of drainage and is crossed by one considerable stream. In this respect the valley is a remarkable one.

The valley has a variable width. It is somewhat contracted to the north, but is greatly widened in the vicinity of Newfoundland, only to be again constricted a few miles south of this village. In the vicinity of the Morris canal, it is ill-defined, owing to the great accumulation of drift and the breaking down of the Highlands on either side. South of Succasunna Plains, it is again broad and well defined, and is known as the German valley. Between Califon and High Bridge, it is again constricted, though this is the lowest part of the valley.

The highest point in the axis of this valley, 837 feet, is the divide between the streams flowing into Greenwood lake and the Pequan-

* Vermeule, loc. cit., p. 141.

nock, respectively. The mountains on the west rise 500 feet (locally 700) above the valley, and those on the east 200 to 300 feet. In that part of the valley drained by the Rockaway, the mountains often rise more than 500 feet above the valley on either side, and the German valley is 300 to 500 feet below its enclosing elevations. The valley throughout is therefore an imposing topographic feature.

On studying the geology (see geological map of New Jersey, also Figs. 1 and 2, Plate II.) of the region occupied by this valley, it is found that most of it is in formations notably softer than those which form its walls, and that its width stands in a definite relation to the width of the outcrop of the less resistant rock. It is narrow where the formations in which it lies have narrow outcrops, and wide where their outcrops are wide, and it becomes narrowest of all (Califon to High Bridge) where the softer rocks fail altogether, and the drainage is forced to cross the resistant crystalline schists. The valley affords another example of the close relationship which exists between the topography of the State and its geology.

The belt of stratified rocks in the midst of the Highlands would have afforded a legitimate basis for the separation of the Highlands into two portions, an eastern and a western. This belt is continuous from the State line to Port Oram, occurs at intervals between Port Oram and Flanders, and is again developed between Naughright and Califon. These stratified rocks, the softer portions of which correspond with the Greenwood lake-High Bridge valley, are by no means equally obdurate. The more resistant portions are even more enduring than the crystalline schists themselves. On the west side of the valley, at its north end, rises the bold Bearfort mountain. Topographically, this belongs to the Central Highlands range; but, farther south, the main valley which separates the Central Highlands range from that to the east, lies west of the ranges which correspond to the Bearfort mountain. Thus, Copperas mountain and Green Pond mountain, lying east of the valley, belong to the range east of the Central Highlands range.

The Passaic range.—East of the Greenwood lake-High Bridge valley lies the third section, counting from the west, of the Highlands. This has been called the Passaic range. Like the Western and Central ranges of the Highlands, its northern end is in New York. The northern end of the Western range fronts the Kittatinny valley just north of the State line (see relief map). It is here cut off by the Vernon valley, which joins the western sub-valley, occupied by the

Wallkill. North of the Western range, the Central range faces the Kittatinny valley. The course of the Kittatinny valley, north of the State line, is more easterly than that of the Central range, and since the northward continuation of the Greenwood Lake valley has less of an easterly trend, the Central range is cut off eight or ten miles north of the State line by the junction of the northward extension of the Greenwood Lake valley with the Kittatinny valley (see relief map). North of this point, the Passaic range, in turn, fronts the Kittatinny valley, to be in turn cut out in the same way as the Central and Western ranges. Its northern end lies southwest of Monroe and Turners, N. Y.

The Passaic range is somewhat lower than that to the west. Its highest points are near the State line, and but a little over 1,200 feet high, a height comparable with the highest points of the Western range. The range is here at its widest, so far as New Jersey is concerned, and it is to be noted that, as in the other ranges, the greatest heights are found with the greatest widths. This range reaches its greatest width, and likewise its greatest height, north of the State line. In New Jersey it reaches an elevation of more than 1,100 feet at but few points north of the Pequannock river, and south of that stream its elevation is still less, with the exception of Green Pond and Copperas mountains, the crests of which rise to 1,200 and 1,300 feet. South of Dover, the highest point is near Mount Freedom, a little over 1,100 feet, but elevations of more than 1,000 feet are rare. The Passaic range continues southward to High Bridge, where the valley separating it from the Central Highlands range is narrowest.

The Passaic range is, on the whole, more dissected, and therefore less plateau-like, than the Central Highlands range, and its separation into more or less isolated elevations becomes more conspicuous near its eastern edge. Less than half its surface reaches an elevation of 1,000 feet. With all its irregularities, it still preserves the most notable feature of the ranges farther west, namely, the general correspondence in elevation of adjacent portions. Where there are distinct ranges, their crests are even. In this respect the Green Pond, Copperas, Bearfort and Kanouse mountains are comparable with the Kittatinny range.

The Ramapo mountain.—The separation of the Ramapo mountain from the Passaic range would hardly be warranted if New Jersey alone were considered (see relief map). The Wanaque river cuts diagonally across the Passaic range, and its valley sets off the Ramapo

mountain from the southwestern part of the Passaic range, but the general characteristics of the Ramapo mountain, so far as it lies in New Jersey, are so nearly like those of the Passaic range, that it need not be considered separately. Its highest point rises to an elevation of something more than 1,100 feet, but most of it is below the level of 1,000 feet.

III. TOPOGRAPHIC FEATURES DUE TO GLACIAL DRIFT.

Throughout the Highlands, including the Kittatinny mountain and valley, there are many minor features which have not been referred to in the preceding sketch. Any good map shows that there are, within the limits of this area, many ponds and lakes. These lakes do not, as a rule, occupy depressions in the surface of the bed-rock, but rather depressions in the drift.* Many of them owe their origin to the damming of river valleys by the drift.

In addition to the basins occupied by ponds, lakes and marshes there are many minor topographic features due to the irregular and apparently fortuitous distribution of the drift. Locally, these features are conspicuous. The drift forms a conspicuous belt of hills just north of Hackettstown, and at various other points along the terminal moraine. These moraine hills are not sufficiently large, in comparison with the associated relief, to be distinct on the accompanying relief map. Notable drift-belts, and irregularities of surface due to drift, occur about Hamburgh, Ogdensburgh, Newton and Peters Valley, as well as at many other points. Notable flats at some points likewise owe their existence to drift deposits, Succasunna plains being an example. Along some of the streams, also, there are distinct terraces of drift. But in general, the topographic features due to drift are minor, in comparison with those which are due to the underlying rock. Topographic features to which the drift gave origin, do not occur over the whole of the Highlands, nor are they absent from all other parts of the State. The relations of the drift, covering as it does mountains, plateaus and valleys, show that it was deposited after the great topographic features of the region had been developed.†

*For an account of the lakes, see Annual Report for 1894, pp. 85–91.

† The topographic features due to the drift are strictly subordinate to those due to the underlying formations. They will be fully discussed in future publications on the drift, and since they are of such minor importance, from the standpoint of general geography, they are here passed with mere mention.

SECTION III.

THE TRIASSIC OR PIEDMONT PLAIN.

This area, intermediate between the Coastal plain on the one hand and the Highlands on the other, comprises nearly one-fifth of the State. Looked upon as a whole, the area is clearly distinguishable from the Highlands on the northwest and from the Coastal plain on the southeast; but along its borders the topographic distinction between it and the neighboring provinces is not sharp. Indeed, its borders, wherever drawn, are likely to find their basis in geology rather than in topography. The northwestern border of this plain is marked by the line which limits the Highlands on the southeast. This line runs from Suffern southwest to the Delaware via Pompton, Boonton, Morristown, Bernardsville, Pottersville, Lebanon, High Bridge and Pattenburg. Its southeastern limit is one with the northwestern margin of the Coastal plain, and is marked by a tolerably straight line running from Woodbridge on the northeast to Trenton on the southwest.

Commencing near Suffern, N. Y., the northwestern border of the plain is distinctly marked topographically as far southwest as Lebanon, in Hunterdon county; but beyond this point its separation from the Highland area can hardly be made on topographic grounds. On geologic grounds the border even here may be sharply defined, but its elevation approaches that of the Musconetcong mountain. Along its southeastern border, the Triassic plain is nowhere sharply marked topographically. Near its margin, its surface has essentially the same elevation as the northwestern edge of the Coastal plain, and a similar topographic expression.

Since the Triassic plain has its slightest elevation where it joins the Coastal plain on the southeast, and its greatest where it joins the Highlands on the northwest, its surface has a general slope from the northwest to the southeast. Since its southeastern edge has the approximate elevation of the Coastal plain which it joins, while the northwestern edge approximates in elevation the southeastern part of the Highlands, its topographic range is considerable. Its surface, moreover, is marked by many notable irregularities—irregularities

much greater in range than those which affect the Coastal plain, and much more obtrusive, because of their more complete isolation, than most of those of equal extent which affect the Highlands (see relief map). Within it occur the crescentic ridges known as the Watchung mountains, or as First and Second mountains, Long hill, and, farther east, the Palisade ridge which fronts the Hudson. Southwest of the Watchungs, Cushetunk mountain and Round mountain are conspicuous, and the Rocky Hill ridge and the Sourland mountain represent further irregularities of surface, if the elevated portions be considered irregularities.

Apart from the Kittatinny mountain range, and possibly the Green Pond mountain and associated ranges, there are no elevations in the State more obtrusive than some of these. Barring these pronounced elevations, the surface of the Triassic plain has but little relief, and, aside from the area between the South Branch of the Raritan and the Delaware, it has but slight elevation. As a whole, the Triassic or Piedmont plain is to be looked upon as having an undulatory surface, sloping gradually to the southeast, and interrupted by conspicuous ridges. Toward the Delaware, especially to the north, the surface rises to such a height, and preserves so nearly level a surface over so great an area, as to merit the name of plateau.

The relation between the topography of the Triassic plain and its geology is not less intimate than the like relationship in other parts of the State. As elsewhere, the notable elevations mark the appearance at the surface of resistant rock. The Palisade ridge, the Watchung mountains, Long hill, the Cushetunk and Sourland mountains and the Rocky Hill range, the most striking elevations of the plain, represent outcrops of hard trap rock, while the plateau between Flemington and Frenchtown, though not of trap, is of rock much more resistant than the soft shales of the lowlands to the east. The Watchung mountains and the Palisade ridge, like the ridges of the more northern portion of the State, are asymmetrical in cross-section, and have their steeper faces to the southeast. The beds dip to the northwest, though at a lesser angle than those of Sussex county.

It is the intervention of the Triassic formation between the Coastal plain proper and the Highlands to the northwest which causes New Jersey to depart most widely from the normal section of the Atlantic slope, as developed farther south.

THE ELEVATIONS IN THE PIEDMONT PLAIN.

The Hunterdon plateau.—Barring a few high points on some of the trap-ridges, the highest part of the Triassic plain is in the western part of Hunterdon county. Not only are the highest points found here, but the high area has so great an extent, and such a surface, as to merit the name of plateau. This plateau is shown on the relief map. The body of it lies between Frenchtown on the west and Flemington on the east. From Flemington to Pattenburg, the Lehigh Valley railway follows the valley which marks its eastern boundary, while the Flemington Branch railway, from Lambertville to Flemington, follows the valley which limits it on the southeast. On the northwest, it is limited by the Musconetcong mountain, and on the west by the Delaware river. On three sides, therefore, it is limited by valleys, and on the fourth by the southwestern spur of the Highlands.

Within this general area, the plateau-like character is best defined about Quakertown, within the area which is bounded on the north by the Cakepoulin, on the northwest by the Nishisakawick, tributary to the Raritan and the Delaware, respectively, on the west and southwest by the Delaware, and on the southeast by the valley occupied by the Flemington Branch railway.

North of the valley of the Cakepoulin there is a dissevered portion of the plateau, known as Barren ridge, which, south of Pattenburg, reaches a maximum height of 900 feet, the greatest elevation within the Triassic area. Farther west, near Milford, is Gravel hill, the next highest point in the Triassic formation of this part of the State. Both Barren ridge and Gravel hill, it is to be noted, are partially cut off from the main area of the Hunterdon plateau.

There is one other small and partially-isolated area, which must be looked upon as a partially-dissevered fragment of the Hunterdon plateau. This is the elevated area just east of Tumble, cut off from the main plateau by the valley of Lockatong creek. The Hunterdon plateau has its counterpart to the southwest in Pennsylvania.

If the valleys between Gravel hill and Barren ridge were filled, and also the valleys between these elevations and the main mass of the Hunterdon plateau, the result would be a gently-sloping surface, the elevation of which would be greatest to the northwest (about 800 feet)

and least to the southeast (500 to 600 feet). Its average rate of southeastward slope would therefore be twenty-five to thirty feet per mile. The highest part of the Hunterdon plateau is to the east, near the South Branch of the Raritan. Thence, it has a slight slope to the west, a slope which is continued to the area east of Tumble. If the Delaware valley were filled, the Hunterdon plateau would be continuous with the corresponding elevation in Pennsylvania.

The Sourland Mountain plateau.—Southeast of the Hunterdon plateau, and separated from it by the broad depression through which the Flemington Branch railway runs, is another elevated tract, somewhat plateau-like, reaching a maximum height of 563 feet, three miles south of Neshanic, and maintaining an average height of 400 feet or more for a considerable stretch. The area is elongate in a northeast-southwest direction, and its axis is just to the southeast of a line from Neshanic, on the Raritan, to Lambertville, on the Delaware. It includes the area known as Sourland mountain, but this name is misleading. It would be better to call it the Sourland Mountain plateau.

If the valley which separates the Sourland Mountain plateau from the Hunterdon plateau were filled to the level of the upland on either side (see Fig. 1, Plate III., p. 32), the former would constitute a continuation of the southeastwardly sloping surface of the latter, the angle of slope diminishing slightly to the southeast. The crest of the Sourland Mountain plateau has a slight slope toward the Delaware, corresponding in this respect with the Hunterdon plateau to the north.

South of the Sourland mountain, there are elevations more or less separated from that plateau-like range, which sustain essentially the same relations to it that the isolated elevations about the Hunterdon plateau sustain to that area. Thus, Moore's hill, on the Delaware, is separated from the Sourland Mountain plateau by the valley of Moore's creek; but for the intervening valley it would clearly be a part of the plateau.

The Rocky Hill range.—The Philadelphia and Reading railway, between Hopewell and Skillman, lies south of the Sourland Mountain plateau. West of Hopewell, the railway passes through the valley which separates this plateau from Rocky hill, a high ridge running off to the east through Cedar Grove to the Millstone and beyond. Rocky hill has a maximum elevation of more than 400 feet, and for more than six miles maintains a height of more than 300 feet.

PLATE III.

EXPLANATION OF PLATE III.

Fig. 1.

Profile from Barren ridge to Stony brook, near Princeton, showing the relative elevations of the crests of this part of the Triassic area. The levels of the crests (Schooley peneplain) are seen to decline to the southeast. The dotted line represents the approximate crest of the Kittatinny base-level, or Schooley peneplain. The oblique lines do not indicate structure.

Fig. 2.

Profile from the north end of Sourland mountain to the north end of Palisade ridge, showing the correspondence in elevation of the crests of Sourland mountain, Second mountain, First mountain, and the Palisade ridge, the crests of which represent the level of the Kittatinny base-level, or Schooley peneplain (dotted line). The oblique lines do not denote structure.

Fig. 3.

Profile from Second mountain, near Paterson, to the Hunterdon plateau, illustrating the same points as Fig. 2 along a line farther northwest.

If the valley between Sourland mountain and the west end of Rocky hill were filled, the slope of the restored surface would be about the same as the slope of the surface farther north restored by filling the depression between the Hunterdon and the Sourland Mountain plateaus. In other words, a line drawn from Barren ridge to the crest of Rocky hill would touch approximately the intervening crests of the Hunterdon and Sourland Mountain plateaus (see Fig. 1, Plate III.)

Of the area thus far considered, the central part, the area about Quakertown, is the part where the plateau-like character is most distinct. On all sides of this central plateau the areas which seem to match it in elevation become more isolated and smaller with increasing distance from it. South and east of Rocky hill, there is no land within the area of the Triassic which seems to correspond with the level of the restored plateau we have been tracing. But to the east of the Quakertown region are Round and Cushetunk mountains, with crests harmonious in elevation with the surface of the Hunterdon plateau. If the valley between them and the plateau were to be filled, the plateau would be extended eastward so as to include them, and, barring the summits of Barren ridge and Gravel hill, the highest point of Cushetunk mountain would constitute the highest point of the plateau.

The valley which separates the Hunterdon plateau from the Cushetunk mountain is but a few miles wide, and with so considerable a stream as the South Branch of the Raritan flowing through it, its origin is at once suggested. East of Cushetunk mountain it is far to any other elevation, the crest of which seems to represent a continuation of the plateau already outlined.

The northwestern portion of the Piedmont plain, north of the Passaic.—Leaving the western extremity of the Triassic plain (plateau) and passing to the northern portion of this zone, a condition of things is found not dissimilar to that already sketched for Hunterdon county. In the northwestern part of Bergen county, and in the extreme northern part of Passaic, there is an area comparable with the Hunterdon plateau. On the west, between Suffern and Pompton, the area is bounded by the Ramapo river; on the south, from Pompton to Paterson, it is limited by the broad valleys of the Pompton and Passaic. Its eastern border is marked by a line running from Paterson to Midland Park, and thence to Hillsdale. Within this area

there is no tract so plateau-like as the region about Quakertown, but there is a tract which, in its general characteristics, is like the surroundings of the Hunterdon plateau; that is, an area made up of a series of elevations coming up to something like a common height, but partially separated by depressions lying below the general level.

Within the area outlined, the highest point is 879 feet above the sea. This is the summit of the High mountain, about five miles northwest of Paterson. There are two or three peaks in this vicinity, southeast of Franklin lake, which rise to heights of more than 700 feet. Farther north, in Bergen county, just south of the State line, there is a tract east of the N. Y., L. E. & W. railway which rises above 500 feet, some points reaching 600 feet. This is separated by lower, though not by very low land, from another elevated area lying north of Crystal lake and Camp Gaw, the highest points of which rise to heights of more than 700 feet. South of the N. Y., S. & W. railway, there are a number of points which rise to heights of more than 800 feet. If the depressions between these partially-isolated elevations were filled up, the result would be a plateau, though its surface would still be somewhat irregular, especially on account of the high elevations southwest of Franklin lake.

East of the area thus outlined and cut off from it by the valley of the Saddle river, is a tract rising to an elevation of more than 400 feet. It in turn is cut off from the Palisade ridge by the deep, broad valley of the Hackensack. Beyond the valley lies the Palisade ridge, a considerable portion of which rises above 400 feet and a small portion above 500 feet. If in the area north of the Passaic river the depressions which separate the elevated tracts were to be filled up to the levels on either side, the result would be an approximate plain (see Figs. 1 and 2, Plate II., p. 16), above the general surface of which would rise a few hills and ridges. These would be located where the hard trap rock comes to the surface through the sandstone and shale. Commencing with an elevation of something more than 600 feet near the Ramapo, this restored plain would slope gently to the eastward. In addition to its easterly slope, its eastern edge, marked by the crest of the Palisade ridge, would have a notable slope to the south. The slope of the restored surface would be comparable to that already noted for the Hunterdon plateau, both in direction and in degree.

The Watchung mountains and Long hill.—South of the Passaic river there is a topography, the elements of which are in harmony with the features already sketched. The conspicuous features of this part of the Piedmont plain are the Watchung mountains (see relief map), the northern ends of which are north of the Passaic, within the area already considered. South of the Passaic, First mountain, the easternmost of the Watchungs, extends from Paterson, south by southwest to Millburn, thence southwest to Bound Brook, and from there northwest to Pluckamin. Second mountain, the second of the Watchungs, lies just inside the preceding ridge. Like First mountain, it is crossed and notched by the Passaic river west of Paterson. South of the Passaic, it extends southwest by south to Summit, thence southwest to Mount Horeb, thence northwest to Pluckamin, and from this point northeast to Bernardsville. Between Mount Horeb and Summit, Second mountain has a double crest, the two being a half-mile to a mile apart. The eastern is, in general, the higher.

Inside Second mountain there is a third line of elevations approximately parallel to it. Between Chatham and Basking Ridge, this line is known as Long hill, a singularly appropriate name. Long hill has not an uninterrupted continuation to the north like First and Second mountains, but Riker hill, near West Livingston, and Hook mountain, running from Pine brook through Whitehall and Mountain View to Pompton, are probably to be looked upon as its continuation.

There is a fourth ridge of still lesser extent lying inside (northwest of) Long hill. It consists of two or three isolated portions lying south of Morristown. The two principal divisions approach each other, the one from the northeast, and the other from the west, at Green Village, a few miles southwest of Madison. These four ridges (five, if the two crests of Second mountain be counted) represent outcrops of as many sheets of trap.

If the topography of the First mountain be studied, it is found to rise on the south side of the Passaic, near Paterson, to a height of between 500 and 600 feet. A little farther south it is interrupted by Great Notch (a wind gap), where the crest sinks to 303 feet. Two miles farther south it again attains an elevation of 500 feet, and from this point nearly to Millburn, the crest nowhere falls below 500 feet, and nowhere rises much above 600 feet. At Millburn, the ridge is interrupted by a wide gap, beyond which it is continued to the south-

west, with a maximum altitude of more than 500 feet. In this part of its course its continuity is broken by narrow notches (valleys) at three points (see relief map). The first of these is west of Scotch Plains (the valley of Green brook), the next at Plainfield (the valley of Stony brook), and the third west of Bound Brook (the valley of Middle brook). To the westward, nearly to Pluckamin, the ridge maintains an elevation of more than 400 feet nearly to its end. While the crest of the ridge declines slightly from the northeast to the southwest, it yet maintains, barring the notches already referred to, a tolerably constant level. Like the Kittatinny range, *First mountain is an even-crested ridge*, notched here and there by sharp gorges. In two places—at Millburn and Paterson—it is interrupted by relatively wide gaps.

The same general relations hold for Second mountain. It is highest to the northwest, north of the Passaic river (High mountain). Its greatest elevation (691 feet) south of the Passaic, is attained just east of Caldwell. Thence it declines slightly to the southwest, maintaining an elevation of more than 500 feet most of the way to Summit. Here the ridge is interrupted much as First mountain is at Millburn. The gap in Second mountain is much narrower than that in First, and the apparent gap is much shallower, but the real gap is much deeper than the present surface shows, since it is largely filled with drift. Southwest of this gap, the eastern of the double crests again reaches an elevation of more than 500 feet, though the range is notched here and there by the valleys of the streams which cross it. Elevations of more than 500 feet, sometimes approaching 600 feet, are found much of the way to Mount Horeb. Farther west, the ridge reaches a height of 653 feet, its greatest altitude south of the Passaic. Elevations of more than 500 feet are found at intervals almost to its terminus at Bernardsville.

The first considerable notch in Second mountain, west of Summit, is Moggy hollow, near Liberty Corner, with an elevation of 331 feet. Barring the pass through which the Passaic flows, this is the lowest pass in Second mountain, as it now stands. There is no corresponding notch in First mountain, for this ridge falls off at Pluckamin, and the drainage through Moggy hollow passes around its north end. The notches in Second mountain are more numerous and less conspicuous than those in First, but this is exactly what would be expected if the streams made the notches, for the streams crossing Second mountain

are smaller than those crossing First. These relations find their explanation in the fact that some of the streams which cross Second mountain unite between First and Second, and the united stream, not its separate parts, crosses the former. Thus, the tributaries of Middle brook make notches in Second mountain at two points, but Middle brook itself, formed by the union of the two tributaries, crosses Second mountain but once. The same is true of Green brook.

It is to be noticed that the elevations of the First and Second mountains are essentially correspondent throughout the whole of their lengths; that, apart from the notches, their crests are nearly even; and that the gaps are of the nature of narrow valleys. Both mountains also have their steeper slopes to the east (west of Middle brook, to the south), and their gentler to the west (or north). In each, the elevation decreases as a considerable stream is approached. Thus both ridges, both north and south of the Passaic, decline toward it, and both decline on either side, as the notches at Millburn and Summit, respectively, are approached. On the whole, Second mountain is rather higher than First, a considerably larger portion of its surface being above an elevation of 500 feet. The double crest of Second mountain has its basis in geology, for Second mountain is really made up of two trap ridges, separated by an intervening narrow belt of sedimentary rock.

Long hill is considerably lower than the Watchung mountains, and this diminished height goes with a diminished width. It has less than half the average width of First mountain, and less than a third that of Second. The northward continuation of Long hill, viz., Riker's hill, and the trap ridges between Pine brook and Pompton, nowhere reaches an elevation of 500 feet, though it frequently exceeds 400 feet. Its elevation throughout, therefore, is harmonious with that of Long hill. It is to be especially noted that the elevation of Long hill, Riker's hill and Hook mountain, lying farther from the sea than First and Second mountains, is somewhat less.

The other elevations already referred to, lying near Green Village, likewise reach an elevation of more than 400 feet, but fail to reach 500. The heights of these ridges, therefore, are about the same as those of Long hill.

Throughout the whole area thus far considered, it is true that, within any limited district, the greatest elevation occurs where there is the greatest expanse of elevated land; that is, within a given area,

the widest ridges are the highest, though a narrow ridge farther from the sea may be higher than a wider one less distant.

Relations of the various crests.—The crests of the First and Second mountains are between one and two miles apart. If the intervening valley—200 feet or so deep—were filled, the two crests would be united into a single plateau-like ridge. If the notches in these ridges were filled, there would be little unevenness of surface, High mountain being the most conspicuous.

The crest of Second mountain is one and one-half to three miles from the crest of Long hill. If the intervening valley were to be filled, the plateau made by filling the valley between First and Second mountains would be widened, but the Long hill edge of it would have a gentle slope to the northwest. By filling the depression between Long hill and the ridges near Green Village, the plateau would be extended still farther—extended, indeed, nearly to the Highlands.

The southwestern end of the Watchung mountains is only about ten miles from the northeastern limit of the Sourland mountain, and the north or north-central portion of First mountain is about equally distant from the Palisade ridge.

If the elevation of the southwestern end of the Watchung mountains be compared with the elevation of the northeastern end of the Sourland mountain, they are found to be nearly the same. Elevations between 500 and 600 feet high are common in both cases. If, then, the broad valley of the Raritan which separates them were to be filled, the south end of the restored Watchung Mountain plateau would be connected with the Sourland Mountain plateau. If the height of the western end of the Watchungs be compared with that of Cushetunk mountain, it will be seen that the latter is somewhat higher; if Cushetunk be compared with the plateau southwest of it, the mountain summit is found to rise above the plateau; but if Cushetunk be compared with Barren ridge, the latter is found to be the higher. The crest of Cushetunk mountain is, therefore, not inharmonious in elevation with its surroundings. By filling the depressions which separate the west end of First mountain from Cushetunk and Sourland mountains, the restored plateau of the Watchung region would become continuous with the restored Hunterdon plateau. The surface of this extended plateau as a whole would slope to the eastward or southeastward, and above its general level would rise some minor elevations, such as the crest of Cushetunk mountain.

Comparing the middle and northern portions of the Watchung mountains with the north end of the Palisade ridge, their elevations are found to be essentially harmonious. A line drawn from the north end of Palisade ridge to Montclair would touch crests of approximately the same altitude at both extremities. Northwest of this line the crests are higher, and southeast of it lower. If a line be drawn from the north end of the Palisade ridge to the east end of Sourland mountain, it would rest at either extremity on crests which have approximately the same height above the sea, and its middle portion would rest on First and Second mountains, where their elevation would be almost the same (Fig. 2, Plate III., p. 32). No one of the four points would vary more than a dozen feet from the elevation of 555 feet.

If another line (see Fig. 3, Plate III.) parallel to the first be drawn to the southwest from the highest point southeast of Franklin lake, it would find there, on High mountain, an elevation of 879 feet, and on Cushetunk mountain, an elevation of 839 feet. Between these points it would have crossed the Highlands northwest of Bernardsville, where it would have touched a summit at an altitude of 857 feet. Farther southwest, on the Quakertown plateau, the same line would find an elevation of 706 feet, the highest point on that plateau.

The Palisade ridge itself departs notably from the other trap ridges in that its crest declines rapidly to the south, reaching sea-level at Bergen Point. It is significant, however, that the decline is toward the sea and that none of the other ridges reaches the coast.

Relation of the crests of the Triassic plain to those of the Highlands.—It has been seen that one of the notable characteristics of the Highlands is the evenness of the crests of its ranges, and the approximately equal height of adjacent mountain masses. So marked is this characteristic that, as has been pointed out, the filling of the valleys between the elevations would give the whole highland country a plane, or but slightly undulating, surface, with a gentle slope to the southeast. It has also been seen that the same characteristics affect the elevations of the Triassic area—whether the long, narrow ranges, such as the Watchung mountains, or the more massive bodies, such as the Hunterdon plateau, be considered—and that by filling the depressions between them a nearly plane surface would be produced, likewise sloping gently to the southeast.

It remains to be pointed out that if the sloping surface of the Highlands, restored as indicated, be extended southeast over the area of the Trias, it becomes continuous with the sloping surface of the latter similarly restored. Stated in other terms, a plain resting at the northwest on the Kittatinny mountain crest and on the southeast on the crest of First and Sourland mountains and Rocky hill, would rest approximately on the crests of all intervening elevations.

The same restored surface, if extended farther to the east, would take in the northern portion of the Palisade ridge, but the southern portion would fall below it. Figs. 1, 2 and 3, Plate IV., help to make these relations clear. They show that restored surfaces of the Highlands and of the Triassic plain fall into harmony with each other in the way described in the text. Northern New Jersey, with its valleys filled, would become a vast plateau sloping southeastward at an average rate of something like twenty or twenty-five feet per mile. To restore this plateau, the principal filling would have to take place in, 1°, the Kittatinny valley; 2°, the basin of Lake Passaic; 3°, the broad Hackensack valley, and 4°, the valley of the Raritan.

The surface thus restored is by no means a primitive one; that is, the structure of the rocks involved is such as to show that the restored surface, if it ever existed, had been developed from some earlier one. Rocks are not formed in the position shown by the accompanying diagram (Fig. 2, Plate II., p. 16). They are known to have this structure, with such topography, only where they have been worn down from some greater height.

THE LOWLANDS OF THE TRIASSIC PLAIN.

Relation to geology.—The Triassic formation is divisible into four parts,* namely, the trap, the sandstones and conglomerates, the black shale, and the red shale. Of these, the trap is hardest, the black shale (in general) next, and the red shale is the least resistant of all. Some of the conglomerate, however, equals the black shale in power of resistance. In general, the elevations already considered correspond with the trap and the black shale, while the lowlands mark the areas of sandstone and red shale.

*See Kümmel. Annual Report of State Geologist for 1896, p. 34.

PLATE IV.

EXPLANATION OF PLATE IV.

Fig. 1.

Profile from the Hudson to the Highlands, near the State line, showing the great depression between the Palisade ridge on the east, and the Ramapo mountain on the west. The crests of the higher areas of the Triassic rock, west of the Hackensack, approach the level of the dotted line running from the Highlands to the Palisade ridge, and with them represent remnants of the Kittatinny base-level, or Schooley peneplain, the old level of which is suggested by the dotted line. The oblique lines do not denote structure.

Fig. 2.

Profile from Bearfort mountain to the Musconetcong mountain, near Swinesburg, showing the approximate correspondence in height of the mountain and highland crests along this line. It shows, also, a slight decline in the crests from northeast to southwest. The areas reaching the dotted line represent the old Kittatinny base-level, or Schooley peneplain. The areas below this line represent later degradation. The oblique lines do not indicate structure.

Fig. 3.

Profile from Ramapo mountain to the Hunterdon plateau, showing correspondence in height of the crests along this line. It shows, also, that the crests decline slightly from the northeast to the southwest. The areas which reach the dotted line represent the remnants of the old Schooley peneplain, and the areas below it represent the work of surface erosion since the development of the Schooley peneplain. The oblique lines do not indicate structure.

Apart from the Palisade ridge, the Watchung mountains, Long hill, etc., the rest of the Piedmont plain, north of the Raritan, is low. Most of it falls below the elevation of 200 feet, though the area of the Great swamp, in Morris county, and a few sandstone ridges between the Palisade ridge and First mountain, rise slightly above this elevation. In that part of the Raritan valley which separates the Watchung from the Sourland and Cushetunk mountains, there is a broad area where the surface is below 200 feet, and for considerable tracts below 100 feet. South and west of the Raritan, the topographic relations are harmonious with those to the north, but there is a large proportion of surface above 200 feet. This is largely because of the considerable development of the resistant black shale in this region. The relief of the lower lands of the Piedmont plain appears to be somewhat exaggerated on the relief map.

The basin of the Upper Passaic.—One of the most remarkable topographic features of New Jersey is the broad flat which constitutes the basin of the Upper Passaic. This is well shown on the relief map. Much of it lies below 200 feet, and little of it rises much above 300 feet. The Watchung mountains, on the south and east, rise nearly 300 feet above it, and the Highlands to the west still higher. The singular feature of the flat is the fact that it is so nearly enclosed. Its outlet at Little Falls and Paterson is the lowest notch in the rim of the enclosure, and the only one through which drainage escapes, and even this is so high that the current above it is very sluggish. If the gaps through which the Passaic crosses First and Second mountains were blocked, water would accumulate in the basin, and the great flat would quickly be converted into a lake. If the blocking were at the pass in First mountain, the water would rise until its surface reached an elevation of 303 feet, when it would flow out through Great Notch, the next lowest point in the rim of the enclosure, and escape by way of the Yantecaw, or Third river, to the sea. If the blocking were in the pass across Second mountain, the water would rise to a level of 331 feet, and then discharge through Moggy hollow, west of Liberty Corner, draining thence into the Raritan. Such blocking would but restore a condition which existed during the glacial period, when the ice-sheet effectually blocked the passes near Paterson and called Lake Passaic into being.* So broad a flat as the basin of extinct Lake Passaic, so nearly hemmed in by

*See Annual Report, 1893, pp. 225-327.

high rock ridges, is an unusual topographic feature. Out of the flat rise Riker's hill and Hook mountain, and across it runs the great drift-ridge between Chatham and Morristown.

The Hackensack valley.—The second notable expanse of low land in the Triassic plain is the broad depression between the Palisade ridge on the east and First mountain on the west, a depression not adequately represented on the relief map. This broad valley is comparable to the Kittatinny valley in the northwestern part of the state, though it is hardly so much below the elevated lands which limit it on either side. Much of it is below 50 feet.

The valley is continued northward into New York, and the divide between the headwaters of the Hackensack and those of the Sparkill creek, flowing to the Hudson, is less that 30 feet above the sea.

Just as in the Kittatinny valley there are low ridges separating shallow sub-valleys, so here there are low sandstone ridges, 100 to 200 feet high, separating sub-valleys comparable to those of the Kittatinny valley. The ridges here, as there, have a pronounced northeast-southwest trend, and are not only serially arranged, but are essentially parallel with the Palisade ridge on the one hand, and with First mountain on the other.

Unlike the Passaic basin, this stretch of low land is enclosed on but two sides. It is broadly open to the south, less broadly to the north. Its average elevation is less than that of the area enclosed by Second mountain, largely because the sub-valleys are more extensive. Its surface, including both the sub-valleys and the divides between them, declines to the southeast as the sea is approached, its eastern part terminating at the south in the broad Newark meadows, while its western portion is continued southwest through Westfield and Rahway and becomes continuous with the third division of the Triassic low land, the basin of the Raritan.

The Raritan basin.—Along the lower course of the Raritan, and including considerable areas along the North Branch and the South Branch above their junction, there is a broad expanse of low land. A wide tract between Metuchen, Plainfield, Bound Brook and Millstone is below 100 feet. To the west the low area rises gradually, just as the lands at higher levels do. The larger part of the territory between Somerville and the Highlands on the northwest, Cushetunk mountain on the west and Sourland mountain on the southwest, lies

between 100 and 200 feet. The same is true of the area east of Rocky hill, southwest of New Brunswick.

It is a notable fact that the area below 100 feet along the Raritan has a much greater extension above New Brunswick, in the vicinity of Bound Brook and Somerville, than farther east nearer the sea. This is in some ways an even more anomalous feature than the great flat enclosed by Second mountain, for in that case the flat is hemmed in by ridges of hard rock; but the rock around Bound Brook and Somerville is, for the most part, the same as that of the higher tracts about New Brunswick on both sides of the river. It is not the drift which makes the surface higher about New Brunswick, because the elevations referred to occur outside the moraine. A broad, flat area of low land, not opening out broadly to the sea, is an unusual condition of things in an unglaciated region where the rock is uniform.

Barring the narrow outlets along the immediate valleys of the Raritan and the Millstone, the low area about Bound Brook and Somerville is shut in by higher lands. If the valley of the Raritan just below New Brunswick were to be filled up to the level of the opposing bluffs—a gorge no more than a mile wide at its top, and still less at its base—the water which now goes to the sea via the Raritan would flow up the Millstone to its junction with Stony brook, thence up Stony brook to its junction with the Shipetaukin, down the Shipetaukin to the Assanpink, and thence down this creek to the Delaware.

If the narrow gorge at Rocky hill through which the Millstone flows were to be filled to a height equal to that of the supposed dam at New Brunswick, a large area about Bound Brook and Somerville would be converted into a lake. The north arm of this lake would run up the North Branch of the Raritan several miles beyond the village of North Branch; the west arm would extend up the South Branch nearly to Flemington; and the south arm would extend up the Millstone as far as Rocky hill. If the outlet for the drainage of the Somerville-Bound Brook-Plainfield area were through the Millstone, instead of through the Raritan, the extension of the low area (below 100 feet) about those places would be less anomalous, since the stream, by this route, would have to cross a bed of hard rock (Rocky hill), through which it might be able to cut but a narrow gorge, while a wide flat was developing above. If the outlet for the drainage was along the line indicated, the conditions for the development of a broad and

low flat about Somerville and Bound Brook would be much the same as in the upper basin of the Passaic. On this interpretation, however, the broad, low flat should have extended farther south in the direction of Rocky hill. Indeed, it should have been limited on the south by the trap.

It is to be noticed that within the lower portion of the Triassic plain there is a considerable expanse of surface at an elevation of 120 to 130 feet. A large area stretching from Metuchen to New Brunswick, and from New Brunswick west to Millstone and southwest to Deans, falls within these limits. Farther southwest there are considerable expanses of surface between Trenton Junction and Princeton, and between Hopewell and the Millstone at similar elevations. Areas of accordant heights are widespread northwest, west, southwest and south of Somerville, though in some of these directions the surface rises without topographic break to elevations of 200 feet or more.

FEATURES DUE TO THE DRIFT.

Within the area of the Triassic plain the surface is much more largely modified by drift than within the Highlands area. This is perhaps partly because the topography had less relief to begin with, so that a given thickness of drift produces greater relative results. But this is not the whole of the explanation, since the drift is much thicker within the Triassic area of the eastern part of the State than elsewhere. While the major topographic features, like the Palisade ridge, the Watchung mountains, etc., are due to rock, many of the minor features are due to drift. Thus the ridge running from Chatham to Morristown is made up wholly of drift. The elevated belt running from Perth Amboy to Fanwood is due largely to drift, and many of the minor features in the Hackensack valley owe their origin to this formation. If the drift were taken out of this valley, its average elevation would be less than now, and its relief greater, some parts even being below the level of the sea. If it were removed from the great swamps lying south and east and northeast of Morristown, in the basin of the Passaic, the surface would be greatly lowered, and the topography altered in details, though not in its greater features. Something of its present flatness would, however, be lost.

The gravel flats flanking the ridge between Madison and Morris Plains, on the southwest, date from the days of Lake Passaic, with which

were also connected the gravel flats about Preakness, Caldwell and Boonton. In these gravel flats there are some striking minor features, such as the great sinks, or "pot holes," near Convent.

The drift is so disposed as to make it clear that the general features of the topography on which emphasis has been laid above, were developed before the drift was deposited, and that the modifications of topography produced by it were superimposed long after the greater features of the region had been shaped.

Comparing the north part of the State with the south—the Coastal plain—they seem, in their topography, to have little in common. In the latter there are few crests which match those of the restored surface sketched in the preceding pages, and the few which might be thought to correspond are so situated as not to make their relations clear. There are, on the other hand, considerable stretches on the Coastal plain which stand at altitudes harmonious with those of the low lands of the Piedmont plain. This is, perhaps, most obvious along the line of junction of the Piedmont and Coastal plains.

TOPOGRAPHY AND DRAINAGE.

The relation of topography and drainage is so close as to impress even the superficial student of a relief map of New Jersey. In the northwestern part of the State, the striking feature of the topography is the marked northeast-southwest trend of ridges and valleys. The larger streams correspond in direction with the ridges. Thus Flat brook and Mill brook, west of the Kittatinny range, the Paulins kill, the Pequest river, the Papakating creek, and the Wallkill river, through most of their courses, run parallel to the great topographic features of the region. The tributaries to these streams join them with transverse courses essentially at right angles to the main streams, yet, even the tributaries show a tendency to assume a northeast-southwest trend, and here and there turn abruptly from their general courses to follow this direction for a greater or less distance. This is illustrated by many streams, but nowhere better than by Trout brook, a tributary to the Paulins kill below Swartswood lake. This brook, in its lower course, runs from northwest to southeast at right angles to the ridges and main streams of the region, but towards its upper end it makes a rectangular bend, and in its upper course has a northeast-southwest direction parallel

to the main valleys. Even the larger streams are subject to these sharp turns. The upper part of Paulins kill makes a right-angled bend at Augusta, and just above Blairstown it makes another turn,

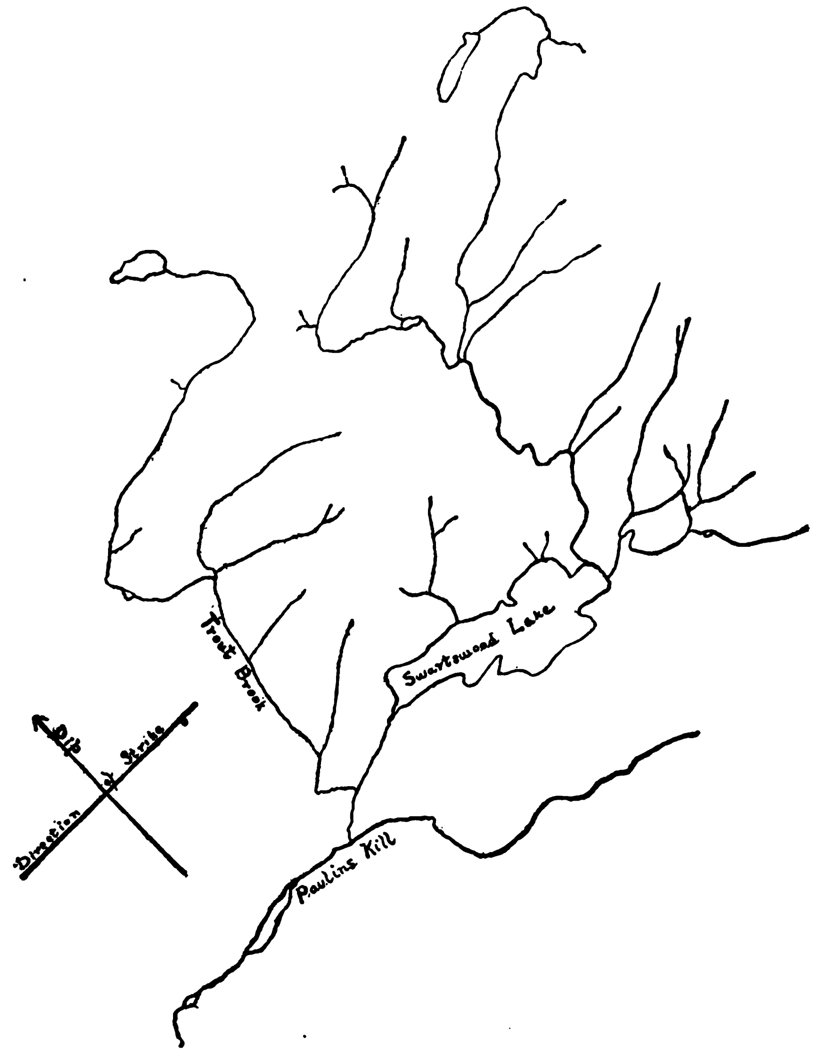

Fig. 3.
Trout brook and its branches.

by means of which it shifts from one longitudinal sub-valley to another a little farther west. The Papakating creek makes a similar bend two miles northeast of Augusta. The tributaries to the tribu-

taries are essentially parallel to the main streams, following a northeast-southwest direction, and their valleys help to emphasize the ridge and valley type of topography prevalent in the region.

It is a notable fact that the streams of the northwestern part of the State, which flow in northeast-southwest courses, have more capacious valleys than those which flow in any other direction, and that where a stream flows partly in a direction parallel to the main features of the region, and partly in a course oblique or at right angles to them, it has a wider valley in the former situation than in the latter.

In the southwestern extension of the Highlands, where limestone belts alternate with the ridges of crystalline schist, there is also marked parallelism between ridges and streams. Here the Pohatcong and the Musconetcong valleys are essentially parallel to the Paulins kill, the Wallkill and the main portion of the Pequest.

In the northern part of the Highlands, the relationship between streams and general topography is somewhat less close. Here, it will be remembered, the northeast-southwest trend in the topography is much less evident than farther west, but yet existent. The largest river (the Pequannock) of the area has a course which is apparently regardless of this trend. Its tributaries, however, follow the trend of the topography. They join their mains from the northeast, flowing toward the southwest, and from the southwest flowing toward the northeast. The tributaries coming in on the northern side are notably longer than those which come in from the south. Some of the streams, like those in the Kittatinny valley, make abrupt turns; thus the Rockaway, after flowing southwest some distance, turns abruptly, west of Dover, and flows east of north.

In the southern part of the Highlands the streams more nearly correspond with the general trend of the broader topographic features. This is seen especially in the valley of the South Branch of the Raritan, above High Bridge, and in the valleys of the Black, the Musconetcong and the Pohatcong. It is to be noted, however, that no stream occupies the long valley which stretches from Greenwood lake on the northeast to High Bridge on the southwest.

The size of the valleys is not always in keeping with the size of streams which flow through them. Thus through the great Kittatinny valley there flows no correspondingly large stream. The Musconetcong and Pohatcong valleys seem disproportionately large, when studied in connection with the size of the relatively small streams

which flow through them. They are disproportionately large when compared with the valley of the Pequannock. Black river also has a valley which seems out of keeping with the small stream which occupies it. All these peculiarities find their explanation in the geology of the region, for, throughout the whole area, the size of a valley seems to be dependent more upon the nature of the rock in which it is excavated, than upon the size of the stream which flows through it. This is nowhere better shown than in the case of the South Branch of the Raritan, which has a large valley from Succasunna Plains southwest to Califon, beyond which it is suddenly constricted, and from this point to High Bridge the stream, which has been gaining in volume from its source, flows through a valley much less capacious than that above. The wide portion of the valley corresponds to softer and less resistant rock, while the narrower portion is through rock less easily eroded.

In the Triassic area the correspondence between streams and topography is less definite. First and last, the Raritan Branches—North and South—flow in almost all directions. The Hunterdon plateau has a general slope toward the Delaware, and the valleys leading to that stream have a northeast-southwest trend in the plateau region; but in the Sourland Mountain plateau this general direction does not hold, and farther south and east the streams assume irregular and apparently anomalous courses. The Millstone and its tributaries seem to flow in courses which have no relationship to the general topography; indeed, they seem to flow contrary to the general slope. They take their source in the low area east of Princeton, and, flowing north, enter a valley in much higher land, crossing the Rocky Hill range in a narrow gorge and escaping thence to the sea by way of the Raritan. A much more natural course for the Millstone would have been in another direction, viz., over to the Delaware by way of Trenton.

In the broad valley between the Palisade ridge and the Highlands, the streams and the topography stand in a relationship to each other which is comparable to that which the streams sustain to the ridges in the northwestern part of the State.

The most marked irregularity of drainage in the Piedmont plain is in connection with the Passaic system. From the headwaters of this system, or from the head of the south part of this system, south of Morristown, the course of the drainage is most circuitous and unnatural (see Fig. 4); yet it is obvious that the great trap-ridges which

Fig. 4.

The Passaic drainage system, as now organized, together with the line (dotted) which indicates the probable site of the master stream in pre-glacial time.

constitute the Watchung mountains are one of the primary factors controlling this peculiar course. From Great Swamp the waters flow south and west to a gap in Long hill, in order to escape from the depression bounded by that ridge. Once beyond this ridge, they flow lazily forward in the valley between it and Second mountain as far as Chatham, where, emerging from the valley, they follow a winding course with sluggish current to the vicinity of Little Falls. Here, reinforced by the waters of the Rockaway, the Pequannock, the Wanaque and the Ramapo, they flow through the gaps in Second and First mountains at Little Falls and Paterson, and so escape to the sea.

It is safe to say that this remarkable system, with its present irregularities, is due to the drift, and dates from the time of that formation. The deep gap in First mountain, near Millburn, has already been mentioned. The rock surface just outside this gap is known to be below the level of the sea, indicating that the surface was very low before the drift was deposited. The gap in Second mountain, opposite that in First, is largely filled with drift. If the drift were removed, its bottom would be found to be lower than the present outlet of the basin at Little Falls. Were it removed, the Passaic river, instead of turning north, between Summit and Chatham, would turn east through this gap and thus escape to the sea. The course it would take is shown by the dotted line (Fig. 4). This would greatly simplify the Passaic system. The course which the stream would follow east of Summit if the drift were removed is not certainly known. It would, perhaps, follow the waters of the upper Rahway for a distance, but probably not to the sea. The course which would be taken probably lies north of the lower Rahway, reaching the salt water perhaps in Newark bay. It seems certain that the drainage from the basin of the upper Passaic once escaped in this direction.

The ridge between Chatham and Morristown, as already indicated, is made up of drift. If this were removed, the drainage from the Great Swamp area would be to the east, *across the site of the present ridge,* instead of by the present circuitous route (see Fig. 4). Once across the site of the ridge it would cross Second mountain at Summit, as already noted, and thence escape to the sea. With the drift blocking in the gap in Second mountain, and the drift ridge between Morristown and Chatham out of the way, the drainage from the Great Swamp area would thus be direct to the sea. This was doubtless the course of the pre-glacial drainage. A large part of the low, swampy

area east of Morristown was probably drained in the same direction. It is even possible, so far as now known, that the Pompton river, made up of the Pequannock, Ramapo and Wanaque, turned south near Mountain View and discharged via Summit. It is perhaps more probable that this system held its present course, and that the area of the Great Piece meadows drained through the same system. The Rockaway, on the other hand, may have joined the more southerly system. The gaps in First and Second mountains, where now crossed by the Passaic, are so great as to necessitate the conclusion that a considerable stream flowed through them before the deposition of the drift. It is to be noted, moreover, that the gap in First mountain, at Paterson, is much less considerable than that near Millburn. This would favor the idea that the larger stream discharged by the latter course. The fact that the gap in Second mountain, at Little Falls, is wider than that in First mountain, at Paterson, would favor the supposition that these gaps were, at least in some part of their history, occupied by a westerly-flowing stream.

SECTION IV.

THE COASTAL PLAIN.

In this report the *Coastal plain* is regarded as co-extensive with the main area of the Cretaceous and later formations, not including the glacial drift; that is, its northwestern boundary is taken to be the same as the southeastern boundary of the Triassic formation, as it now appears at the surface.

Outside the State, it is the common impression that most of the area lying southeast of the Pennsylvania railway is low, flat and sandy, and, in addition, essentially desert. Examination of the relief map which accompanies this report, and of the excellent topographic atlas of the State, shows that this general impression is far from true, so far as regards elevation and flatness. The sections on Plate V. convey some idea of the surface of the plain. Within this plain, too, lie the most fertile lands of the State, though they are less uninterrupted than could be desired. While there are somewhat extensive flats, both along the coast and in the interior of this portion of the State, these flats are of different levels. Some of them, especially those along the coast, have an altitude of no more than 40 feet; others, such as those about Hightstown and Old Bridge, are 130 to 150 feet above the sea; while in the vicinity of Whitings and Woodmansie there are plains which approach an elevation of 200 feet.

Even this is not the measure of the relief of Southern New Jersey. There is a notable range of elevations extending in a northeast-southwest direction from the Navesink highlands on the northeast to Mount Holly on the southwest, the highest of which approach 400 feet in elevation. Since they are somewhat isolated, they are striking topographic features.

The study of the relief map, and of the contoured maps as well, shows clearly that the irregularities of surface which affect Southern New Jersey are for the most part closely associated with the streams. Every stream runs along the axis of a depression, and the correspondence is so close as to necessitate the conclusion that the depression and the streams were associated in origin. The larger part of the southern portion of the State may, therefore, be looked upon as a plain, highest

PLATE V.

EXPLANATION OF PLATE V.

Fig. 1.

Profile from near Frenchtown, on the Delaware, to Chadwicks, on the east coast, showing the Piedmont plain to the west and the Coastal plain to the east. The oblique lines do not indicate structure.

Figs. 3, 4 and 5.

Profiles across the Coastal plain between the points indicated on the sections.

toward its middle and lowest about its margins, the surface of which has been trenched by the streams which flow over it.

Though the highest elevations in the Coastal plain reach an altitude of nearly 400 feet, by far the larger part of its area has an elevation of less than half this amount. Of the 4,400 square miles embraced within its limits, nearly one-third does not reach an elevation of 50 feet, and about 12 per cent. of this has an elevation of less than 4 feet. This is the tidal-marsh. Nearly two-fifths of the area of the Coastal plain lie between the elevation of 50 feet and 100 feet, and only a little more than one-fourth (1,200 square miles) rises above 100 feet. There are many points which rise above 200 feet, but their aggregate area does not exceed 15 square miles. The highest elevations, including all that rise notably above 200 feet, are in the narrow belt referred to above, running from the Navesink highlands on the northeast to Arney's mount on the southwest.

THE AREA BELOW AN ALTITUDE OF FIFTY FEET.

It is not to be understood that the area of the Coastal plain below 50 feet in elevation is sharply separated from that at higher levels. There are somewhat extensive flats about the coast ranging up to heights of rather more than 40 feet, but their inland borders are not clearly defined. The area below the 50-foot contour is, therefore, an ill-defined natural division in the topography of the Coastal plain.

A border belt.—That portion of the Coastal plain which is below 50 feet in altitude is disposed as an irregular border-belt (see Plate VI., p. 58), extending along the Delaware river and bay from Camden to Cape May and thence along the Atlantic coast from Cape May to Raritan bay. Within this belt there is but one place where land 50 feet in height reaches the immediate shore. This is in the Navesink highlands.

The line marking the inner border of the belt of land below 50 feet is notably more irregular that the present coast-line. Disregarding these marked irregularities, the belt is widest along the lower course of the Delaware river, in Gloucester, Salem and Cumberland counties, and at the extreme southern portion of the State, in Cape May county. In this county, indeed, there is but one point, and that is in its extreme northwestern part, which rises to a height of 50 feet, and this

to but 54 feet. From Cape May, due north, it is about 35 miles to the nearest land more than 50 feet above the sea.

So variable in width is the belt of land below the level of 50 feet that its average cannot easily be stated. It is more than five miles in width from Bridgeport, on the Delaware, to Somers Point (Great Egg Harbor), not counting the beach and tide-marsh. If these be added, the belt of low land five miles in width would be extended northward along the east shore to Manasquan.

The great irregularities in the width of the low border belt occur in the lower parts of the main drainage basins, where it has a great extension inland. If the Coastal plain portion of the State were to sink 50 feet, the outline of the remaining land would be very much more irregular than now (see Plate VI.*), and the lower portion of every considerable valley would be converted into a bay, penetrating far into the interior. Commencing on the Delaware river, the line marking the inner limit of the area below 50 feet extends inland along every considerable stream from Camden to Raritan bay. Even north of Camden, as far as Bordentown, most of the creeks flow through valleys the lower parts of which are below the 50-foot contour. Thus the Assiscunk, Rancocas and Pensauken creeks, north of Camden, have wide valleys below this level, and along Cooper's, Timber, Mantua, Raccoon, Oldman's, Salem, Alloway and Cohansey creeks and the Maurice river, the low area extends far back into the interior.

The streams along the Atlantic coast are likewise associated with low areas, running beyond the general border belt. Thus about the Tuckahoe, Great Egg Harbor, Mullica, Wading, Forked, Tom's, Metedecunk, Manasquan, Shark, Swimming and South rivers, as well as along many of the minor creeks, the low border belt finds considerable extension inland. From Great Egg Harbor inlet up the Great Egg Harbor river it is about 30 miles before an elevation of 50 feet is reached, and throughout most of this stretch there is a plain of some width below 50 feet. Up the Mullica river, from its entrance to Great bay, it is even farther before the bed of the stream reaches an elevation of 50 feet, and its various branches are bordered by plains still wider than those associated with Great Egg Harbor river.

* There would be many small islands, not shown on the map, if the State were to sink as here indicated. The map is no more than an approximation, but shows the general relations.

Another extensive plain below 50 feet along a river system is that in the drainage basin of South river. This, like the plain in the drainage basin of the Rancocas, is especially notable in that it is wider inland than at points nearer the shore—a feature which, it will be remembered, characterizes the basin of the Raritan (see p. 45). These relations are shown on the accompanying relief map.

A large part of the area below 50 feet is nearly flat. With this elevation great relief would of course be impossible; but an elevation of 50 feet so near the sea would allow of much greater relief than this area, as a whole, possesses. Within it there are a few isolated areas, usually small, which rise above 50 feet. These are especially likely to occur near the inland border of the belt. In general, however, the areas rising above the level of 50 feet within the 50-foot belt are small and but slightly above this level, and are not conspicuous topographic features.

The most striking elevations in this belt, often as conspicuous by reason of their isolation as because of their height, occur in Monmouth county. The isolated hills on Rumson Neck, east of Red Bank, and certain isolated hills in the vicinity of Long Branch, are the most notable, but the elevations on Rumson Neck, as well as some of the others, not only rise above 50 feet, but above 100 feet.

Tidal marshes.—It has been calculated by Mr. Vermeule * that 660 square miles of New Jersey, including some small water areas, are tide marsh. This estimate includes the tide marshes of the valley of the Hackensack. Excluding these, the tide marsh area of the Coastal plain constitutes about 12 per cent. of its area. The tide marsh lies principally between the beach of the Atlantic coast and the mainland within; but there is also a tide marsh border fronting Delaware bay, unprotected by a beach. From Metedecunk creek to Monmouth Beach, both the tide marsh and the beach are absent.

The width of the marsh varies greatly. North of Barnegat village it does not exceed a mile in width. South of this point it widens, encroaching more and more on the bay which lies between the beach and the mainland. About the debouchure of Mullica river, and just below Great bay, it has its greatest width. Including the "thoroughfares" or waterways within it, it has a width of five or six miles between Great bay and Atlantic City. To the south, it is somewhat narrower, but still retains an average width of two or three

* Geological Survey of N. J., Vol. I., 1888, p. 178.

miles, and has a considerable expansion about the mouth of the Tuckahoe and Great Egg Harbor rivers.

It is to be noticed that the tide marsh, like the low land below 50 feet, has its greatest extension at the debouchures of the larger streams, notably the Mullica, Great Egg Harbor, and Tuckahoe. Along Delaware bay the marsh reaches a width of five miles in but one place, viz., at Egg Island point, and in general is less well defined than along the Atlantic.

About Raritan bay, tide marshes are found along the lower courses of the streams, especially of Raritan and South rivers, and Chesquake creek.

The beaches.—The "beaches" are the low, narrow ridges of sandy land lying off the mainland along the ocean front. Beaches occur along most of the east coast, being absent only from Monmouth Beach to Manasquan. The beaches, as they now appear, are made up chiefly of dunes. Originally they were barrier ridges constructed by the waves a little off shore in shallow water. The position of the ridge on any part of the coast marked the position where the incoming waves broke, and dropped much of the sand which was being carried along the bottom. In storms the sand of these barriers was piled up above the normal water level, and, on becoming dry, was tossed up into the existing hills and ridges by the wind. The shallow water between the beach and the mainland, shut off from the ocean, is gradually being silted up by sediment washed in from the land. As the water becomes sufficiently shallow, vegetation gets a foothold, and the marsh is formed. Ultimately the depression between the beach and the mainland will be filled up, except where scoured by the ebb and flow of the tides.

AREA BETWEEN FIFTY AND ONE HUNDRED FEET.

The upper limit of this belt is still more arbitrarily defined than the upper limit of the last. The only natural topographic division of the Coastal plain which might be made above the 50-foot contour, would not be limited by a horizontal line. In some regions, as in Mercer, Somerset and some parts of Middlesex counties, there is a natural line of division at an elevation of 120 to 130 feet. As will be seen later, this marks locally the limit of the Pensauken submergence; but the line marking the limit of this submergence is in some

places higher (150 to 160 feet) and in some places lower (90 to 100 feet). There is no horizontal line of division above the 45 to 50-foot level which is not arbitrary, and that here given is perhaps not more arbitrary than any other horizontal line would be.

Of the 4,400 square miles in the Coastal plain, about 1,700 are between the altitudes of 50 and 100 feet. The disposition of the land between these limits is still more irregular than that of the lower belt. On the accompanying map (Plate VII.) all the land of the Coastal plain below 100 feet in elevation is shaded. From this it will be seen that if the State were depressed 100 feet, less than one-third of the Coastal plain would remain above the sea, and that even this relatively small area would be in the form of an archipelago, made up of two large and many small islands.* From the map it will also be seen that some parts of the area outside the Coastal plain, as here defined, would likewise be submerged.

In general, it may be said that the area between 50 and 100 feet lies just inside that below 50 feet. It has been pointed out that the inner border of the lower belt is very irregular, extending far inland along the drainage lines, and the inner border of this belt forms the outer border of the belt between 50 and 100 feet. The outer border of this belt is therefore very irregular, and its inner border, like the inner border of the lower area, is extended notably inland along the valleys; but in this case it happens that it extends so far inland from opposite sides that the extensions from east and west sometimes meet. Thus, following up the broad valley of the Mullica, the divide which separates its drainage from that of the headwaters of the Rancocas creek, is in several places below 100 feet. The divides between the South river and Lawrence's brook, between Lawrence's brook and the Millstone system, and between the latter and Assanpink creek, are all less than 100 feet above tide. A sinking of 100 feet would cut off that portion of the Coastal plain which remained above water from the northern part of the State along the line of the Delaware and Raritan canal, and sea water would also cross the State from east to west, from Great bay to the Delaware river, via Marlton, Medford and Vincentown.

There is another point of view from which to look at the surface lying between elevations of 50 and 100 feet. In some places the areas between these limits are somewhat extensive, and nearly flat.

* There would, in reality, be many small islands not shown on the map.

In others they are extensive but possess more relief; and in still others they consist of isolated hills or ridges only, rising above areas which are otherwise below 50 feet.

The isolated hills and ridges which rise to elevations of more than 50 feet from surroundings below that level, lie for the most part near the inner border of the 50-foot plain, and consequently near the outer border of the 50–100-foot belt. Thus along the Delaware river there are a few isolated hills and ridges of greater or less size, between Woodbury and the lower part of Cohansey creek, the crests of which are between 50 and 100 feet. There are a few also in the extreme southern part of the State, and along the Atlantic coast. In general, these isolated areas are smaller the farther they are outside the limit of the 50–100-foot belt, and larger the nearer they are to the border of the large areas of corresponding altitude. This is shown by a glance at the map (Plate VII.) The areas between the limits under consideration are most nearly level where most extensive. Thus the broader divides between the Mullica and the Great Egg Harbor rivers, and between the Maurice and Great Egg Harbor systems, possess surfaces which approach most nearly to flatness. They are, however, by no means without relief.

The belt of land below 50 feet along the Delaware river is much wider below Camden than above, but the belt of land between 50 and 100 feet is much wider between Camden and Trenton than below the former city. In the larger area of the former region, there are more nearly level stretches between 50 and 100 feet, than in the smaller area of the latter. The area east and northeast of Trenton is, perhaps, the flattest area within the State within the altitude limits here considered.

Just as the area below 50 is marked, especially near its inner border, by isolated tracts of higher altitude, so the inner border of the belt between 50 and 100 feet is marked by occasional elevations above 100 feet. Indeed, the elevations in this area are, on the whole, more common and more conspicuous than the hills and ridges which rise above the level of the lower area. On the lower level, there are few elevations comparable to the Juliustown mount, Arney's mount, Mount Holly, Taylor's mount, Mount Laurel and numerous unnamed hills about Hampton Gate, south of Marlton, at Taunton, and at various points near the eastern coast. The most nearly corresponding elevations rising above lower level are those in northern Monmouth

county, and here some of the most conspicuous, as already pointed out, rise above the 100-foot level. On the whole, the area between 50 and 100 feet, although farther from the sea, has relatively more relief than the lower land.

THE AREA ABOVE ONE HUNDRED FEET.

If the State were to be sunk 150 feet, most of the large southern islands which would remain after a submergence of 100 feet would have disappeared beneath the sea. The northern of the two large areas shown on Plate VII. would likewise have suffered loss, and its remnants would be dissevered. The largest continuous land mass would be in the vicinity of Whitings and Woodmansie.

A submergence of 200 feet would leave but a few points of the Coastal plain above the sea, and these would be chiefly in a single belt running from Navesink highlands, on the northeast, to Arney's mount, on the southwest. Outside this range there would be a group of small islands north of Farmingdale—the crests of the Hominy hills—one small island west of Cassville, about a dozen in the vicinity of Whitings, Woodmansie and Shamong, in Ocean and Burlington counties, and two in Camden county, near Berlin and Clementon, respectively. Outside the Navesink highlands-Arney's mount range, not one of these islands would rise 15 feet above the sea, but the height of the highest of this range would be nearly 200 feet.

The most nearly level land of the Coastal plain above an altitude of 50 feet lies between the 120 and 150-foot levels. This is found in the broad belt lying just below 150 feet, extending from Old Bridge, on the northeast, to Allentown, on the southwest, in the region between Bridgeton and Glassboro, and between Vineland and Williamstown. Even here the plainness affects only the broad divides more remote from the streams. The general character of the surface between 150 and 200 feet is rougher than that between 100 and 150 feet, but the difference is not always great.

The areas above 200 feet consist of nothing more than isolated hills, usually of small extent. Their position has already been indicated.

STRUCTURE OF THE COASTAL PLAIN.

The formations of the Coastal plain are beds of clay, sand, marl, etc., mostly unindurated, and with a slight dip to the southeast. The absence of great inequalities in hardness, and of high dips, explains in part the absence of notable and asymmetrical ridges. Locally, however, the sand, gravel or marl is cemented into more or less solid rock. This cementation is generally local, and not always in definite beds. It is more likely to occur at the junction of beds of different texture than elsewhere. In some cases cementation has gone so far that the rock is quarried. Many of the most conspicuous elevations of the Coastal plain are capped by cemented beds of gravel (conglomerate), sand (sandstone) or marl, while many others, such as the Hominy hills, are of material so loose and porous that the rainfall sinks into them, instead of running off over their surfaces. Since it is the water which runs off over the surface which does the greatest amount of eroding, the outcrops of the most porous beds sometimes have great elevations. There are few conspicuous hills, high or low, in the Coastal plain, which are not protected by a cap of rock, or of loose gravel.

If the valleys of the Coastal plain through which the streams flow were filled to the level of the limiting elevations, the restored surface would be essentially a plain, though with some slight relief. In general, it would be highest along a curved axis running from Freehold, through Whitings, to Berlin and Glassboro. From such an axis the surface would decline to the southeast, south and northwest.

The filling necessary to restore this surface would be greater in some places and less in others. In general, it would be greatest along the larger streams, such as the Mullica, Great Egg Harbor and Maurice rivers and Rancocas creek. It would also be great along the broad, low trough extending from the head of Raritan bay to Trenton.

Above the general level of the plain would stand the Navesink-Clarksburg-Arney's mount range of hills, the highest of which would rise 200 feet or so above the higher part of the plain on which they would, under the supposed circumstances, stand. They would be comparable to the elevations above the general level of the restored plain in the northern part of the State, already considered (p. 40).

This plain, however, is long subsequent to the northern plain in origin, for its strata were not yet deposited when that was developed, as will be seen in Part II. of this report.

PART II.

THE HISTORY OF THE TOPOGRAPHY.

SECTION I.

EROSION PLAINS. BASE-LEVELS.

Having given a brief sketch of the topography of the State in the preceding pages, we come now to the consideration of its origin.

THE RESTORED SURFACE OF NORTHERN NEW JERSEY.

It has been seen that, by filling the many valleys in the higher lands of the northern part of the State, a nearly plane surface would be reproduced, the relief of which would be slight, and the slope of which would be to the southeast (see Plates II., III. and IV., pp. 16, 32 and 42). Above its general level there would rise a considerable number of low hills and ridges, such as High point on Kittatinny mountain, and the summits now rising above an altitude of 1,200 feet or so in the northwestern part of Passaic county. These hills and ridges, rising above the general level of the restored plain, would rarely exceed 100 feet, and probably never 250 feet in height. While, therefore, the restored surfac3 would lack absolute plainness, its relief would be but slight, and its approach to smoothness close.

It has been pointed out that the relation between streams and topography is very close. This relation is by no means peculiar to New Jersey, but is to be found in all lands where streams flow. It is only necessary to recall the familiar fact that streams uniformly flow through valleys, deep or shallow, to bring this relationship

clearly to mind. Nor is there any question as to the meaning of this association. While large topographic features, or even minor ones in some cases, determined the courses of the valleys, it is still true that the streams, together with the antecedent and accompanying processes which gave rise to them, have been the chief agents in making the depressions through which they flow. Since the streams have made the valleys, the filling of these valleys would but restore the surface which existed before they were excavated. The restoration of the plane surface referred to in the preceding pages, is therefore not fanciful; it is but a way of getting a clear conception of the sort of surface which preceded the present. If then we conceive the valleys of northern New Jersey to be filled to the level of their bounding bluffs, the result would be a surface such as would exist if the work of the streams and their immediate antecedents were undone. That such a surface existed at some time in the distant past cannot be doubted. Was this surface original, or was it developed from some yet earlier condition? To answer this question it is necessary to look briefly to the geological structure of this part of the State.

THE STRUCTURE OF NORTHERN NEW JERSEY.

The geological structure of the northern part of the State is shown by Fig. 2, Plate II., p. 16.* The section is drawn from the Delaware river, between Dingman's Ferry and Wallpack Center, to the Hudson at Jersey City. It shows that the strata along the line of the section are everywhere highly inclined, and in some places folded. The restored surface, reproduced by filling the valleys, would have a structure identical with that which now exists, for the restoration would consist simply in carrying the edges of the inclined strata of the valleys up to the level of the adjoining highlands.

THE ORIGIN OF THE STRATA.

The rocks of northern New Jersey are largely of sedimentary origin. Their structure, their constitution, and their general relations show that they were formed beneath water, while their fossils show that this water was the sea. Barring a few small areas of igneous rock, a

* This section is copied from that given by Cook on the map published in 1890.

marine origin is certain for all the strata of the Kittatinny valley and mountain, and for the strata which make up the Green Pond, Copperas, Kanouse and Bearfort mountains, as well as for those which underlie the Greenwood lake-High Bridge valley throughout most of its course. The same is essentially true for the sandstone and shale of the Triassic plain, for even if this formation originated in an enclosed sea of brackish water, as has been conjectured, the problem is not notably changed. It is still a formation made beneath water, and probably water at or near sea level.

Without entering into a discussion of the subject, it may be said that most of these sedimentary strata are nothing more nor less than hardened beds of mud (shale), sand (sandstone), and gravel (conglomerate). The materials of which they are composed were brought to the sea by rivers, or were worn from the shores by waves. The limestone likewise originated beneath the sea, being either the product of shells, corals, etc., or a precipitate from sea water, or both. All sediments deposited in the sea, or in standing water, are spread out in beds which are nearly horizontal, and such must have been the original position of these beds. The trap, on the other hand, is igneous rock, some parts of which were injected into the sedimentary strata after the latter were laid down, while other portions were poured out on the surface of the sedimentary beds, and subsequently covered by later deposits. It is not now possible to say to what extent the crystalline schists of the Highlands are altered or metamorphic sediments, but it is certain that at least some of them had such an origin.

THE ORIGIN OF THE PLAIN.

Starting, then, with the premise that many, if not most, of the beds of rock in the northern part of the State were formed beneath the sea, and in a horizontal position, it is clear that they have been subject to great disturbance since that time. This being true, it is clear that the restored surface shown in profile in Fig. 2, Plate II., as well as in the other sections on Plates II., III. and IV. (pp. 16, 32 and 42), was not formed by the simple, equal uplift of the sea bottom on which the beds had accumulated. Simple uplift should have left the strata in a nearly horizontal position, while, as a matter of fact, all of them are highly inclined, and many of them are nearly

on edge. Simple uplift of the sea bottom, on which the sedimentary beds accumulated, is therefore not the origin of the restored plane surface of northern New Jersey.

There is apparently but one way in which the restored plane surface, with the existing rock structure, could have been brought into

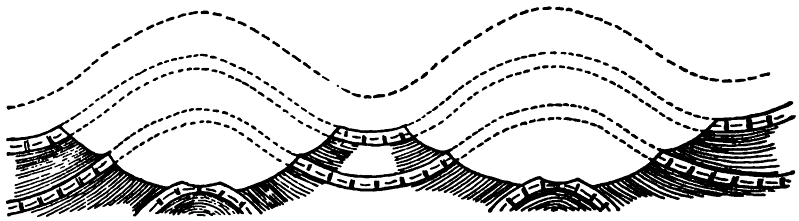

Fig. 5.
Illustrates positions which strata may assume with reference to the surface, after gentle folding and subsequent erosion.

existence. If, in the elevation of the beds of sedimentary rock, the strata were tilted or folded, they might have been inclined at almost any angle—depending on the degree of folding (see Figs. 5 and 6). That tilting and folding of sedimentary beds have taken place many times in the earth's history is witnessed by the many mountains produced by the folding of the strata of the outer portion of the earth's crust.

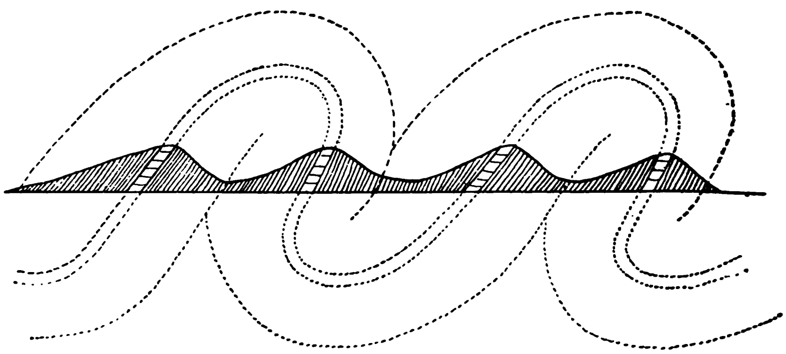

Fig. 6.
Illustrates the way in which the strata of a region may all come to be inclined in a given direction at a nearly constant angle.

If strata, after having been folded and lifted high above sea level, were by any process cut down to a level or nearly level surface, much lower than that to which they had been lifted, the result of the cutting would be a plain, the structure of which would be com-

parable to that which affects the restored plain of northern New Jersey. Not only this, but this is the only way, so far as now known, by which a plane surface, with such a structure, could be developed. We must believe, therefore, that the restored plane surface of northern New Jersey was not an original surface, but one which had been developed from some earlier condition by the cutting off or truncation of the tilted and folded strata. That such truncation has taken place, there can be no doubt, for the strata which in Fig. 2, Plate II. (p. 16) appear to be abruptly cut off at the top, must have had an upward continuation at the time they were first elevated from their horizontal position, and thrown into folds or inclined at high angles. The restored plain of northern New Jersey is therefore a truncated surface. It is the starting point for the study of present topography, but it is a surface which had a long antecedent history, and its origin must now be sketched.

It should be recalled that the strata of northern New Jersey vary greatly in hardness. Yet in spite of their unequal resistance to erosion, it has been pointed out that neighboring crests correspond closely in height. Even on the restored plain, however, the outcrops of the harder strata appear not to have been reduced to the level of their surroundings, but to have constituted low ridges, on the otherwise base-leveled surface.

There are two conceivable ways in which a level or nearly level surface could be produced by the degradation of an earlier and higher one. Either of these processes would be applicable to horizontal strata, or to inclined or folded beds, and either would be measurably independent of structure. A plane surface at a low level might be developed from any sort of surface of greater altitude, either (*a*) by subaërial agencies, such as rain, rivers, winds, glaciers, etc., which might reduce a surface to a new and lower level after it was elevated; or, (*b*) by the sea, which, at many places, is even now encroaching upon the land along its shores, leaving a plane, submerged surface in the area over which it has transgressed. Given sufficient time, the sea might cut far back into land masses, developing, in the process, a plane surface just below the depth of effective wave action, where rough surfaces, or plane surfaces at higher levels, had previously existed. Subsequent uplift might bring this submerged and wave-planed surface above sea level. There is, so far as known, no third way by which a plane surface with such a structure as that shown in

Fig. 2, Plate II., could have been produced. Plains developed in these ways are known as *plains of subaërial denudation*, and *plains of marine denudation*,* respectively. There is the best of reason for believing that the old plain of northern New Jersey, from which the present topography has been developed, was formed in the first of these two ways. In the following pages such an origin will be assumed.

HOW RIVERS WORK.

It is here worth while to depart from the immediate forms of surface presented by New Jersey, in order to study very briefly the simple general results of river erosion.

If a land surface were to come into existence by the elevation of an area of sea bottom, the strata suffering only such disturbance as simple uplift necessitated, the surface of the resulting land mass would be approximately smooth, as the surfaces of land masses go. That the surface of such a land mass would as a rule not be rough, is evident from the fact that the bottom of the sea is usually rather smooth. Much of it, indeed, is so nearly plane that if the water were withdrawn, the eye would scarcely detect departure from plainness. The sort of surface which a land mass elevated from beneath the sea would possess, would be similar to that which would exist in southern New Jersey, if the shallow valleys of the Coastal plain were filled.

Let it be supposed for the sake of the conception which it is wished to gain, that an area of land formed by the elevation of the sea bottom reaches an altitude of several hundred feet. So soon as it appeared above the sea, the rain falling upon it would begin to modify its surface. Some of the water would sink beneath the surface, and find its way underground to the sea, while some of it would run off over the surface, and would perform the work characteristic of streams. The run-off would tend to gather in whatever slight depressions there might be in the surface, just as water gathers in little rivulets on a hillside, wherever there are irregularities of slope. The water concentrated along these lines, being in excess of that flowing over other parts of the surface, would flow faster; flowing faster, it would erode the surface over which it flowed more rapidly. Thus along the

*For criteria distinguishing these two classes of plains, see Davis, "Plains of Marine and Subaërial Denudation," Bull. Geol. Soc. of America, Vol 7, page 377, 1896.

lines of principal flow *washes or gullies* would be started, just as they may be seen to start on hill slopes to-day under favoring conditions.

Once started, each wash or gully would in some sense be the cause of its own growth, for the gully developed by the water of one shower, affords opportunity for greater concentration of water during the next. Greater concentration occasions faster flow, and faster flow means more rapid erosion, and this means enlargement of the depression through which the flow takes place. After a gully is started, each succeeding shower increases its size, and that in all dimensions. The water coming in at its head, causes its head to be worn back into the land, thus lengthening the gully; the water coming in at its sides wears them back, thus widening it; and the water flowing along the bottom deepens it. Thus gullies grow to be ravines, and further enlargement by the same processes converts a ravine into a valley.

When by the help of successive showers, a valley has been sunk below the underground water surface (the level to which it would be necessary to sink wells in the same region), water will seep into it, and a more or less permanent stream is born. From that time on, the valley is not immediately dependent on showers for its supply of water. It is to be noted that a permanent stream does not normally precede its valley, but that the valley, developed through gully-hood and ravine-hood to valley-hood by means of the temporary streams supplied by the run-off of occasional showers, *finds a stream*, just as diggers of a well find water. If a valley be supplied with water by springs, it is as true to say that the valley found the spring, just as "veins" of water are found or "struck" in digging wells, as that the spring found the valley.

The following diagram (Fig. 7) will help to make the suggested

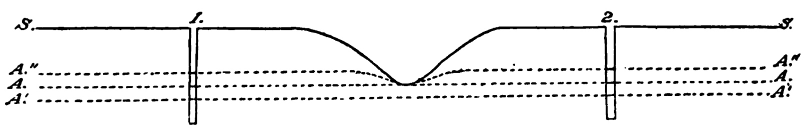

Fig. 7.
Illustrates the relations of ground-water to streams.

relations clear. The diagram represents a vertical section of porous earthy or rocky matter, *s s* being the surface. At 1 and 2 wells have been sunk, and between them a valley is seen in cross-section. The line $A'' \ A''$ represents the usual level of the underground water

surface, and the level at which the water stands in the wells, under ordinary circumstances. The bottom of the valley being below the level of the ground-water, the latter tends to seep into it from either side, and to fill it to the level *A*. But instead of accumulating in the valley as it does in the wells, it flows away, and the water level on either hand is depressed. Under these circumstances the stream is constant.

The level of the ground-water fluctuates. It is depressed when the

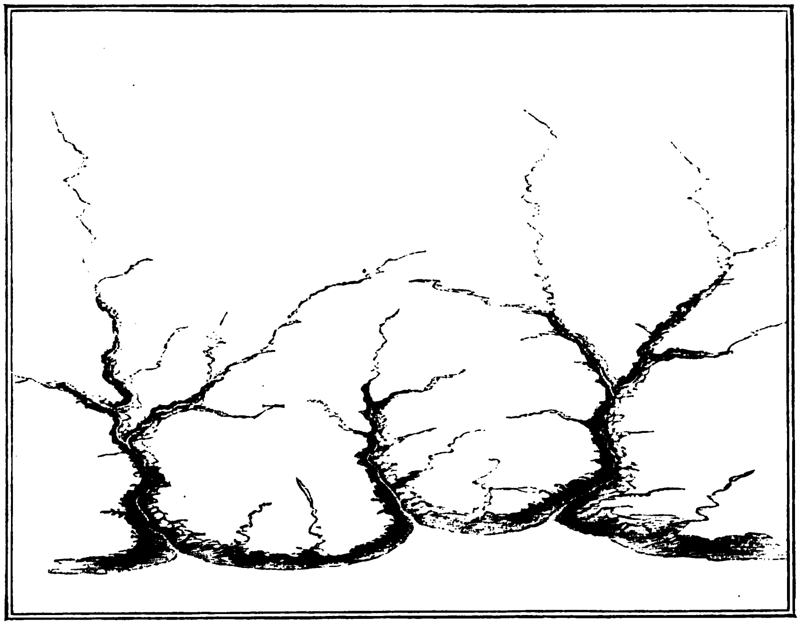

Fig. 8.
Young valleys.

season is dry, and raised when precipitation is abundant. In the latter case it may be raised above *A″ A″*. The water in the wells then rises, and the stream in the valley is swollen. In a dry season, the ground-water surface may be depressed as low as *A′*, when the stream would cease to flow. Streams which flow during the wet season and go dry during the dry season, are thus illustrated. Ultimately the valley may be worn below the level of the ground-water in the driest season, and the stream is then permanent.

If, along the borders of a new-born land mass, a series of valleys were developed, essentially parallel to one another, they would constitute depressions separated by elevations, representing the original surface not yet notably affected by erosion (see Fig. 8). These inter-valley areas might at first be wide or narrow, depending on the position of the valleys, but in the process of time they would necessarily become narrow, for, once a valley is started, all the water which enters it from either side helps to wear back its slopes, and the wearing back of the slopes means the widening of the valleys on the one hand and the narrowing of the inter-valley ridges on the other. Not only would the water running over the slopes of a valley wear back its walls but many other processes conspire to the same end. The wetting and the drying, the freezing and the thawing, the roots of plants and the borings of animals, all tend to loosen the material on the slopes or walls of the valleys, and gravity helps the loosened material to descend. Once in the valley bottom, the running water is likely to carry it off, landing it finally in the sea. Thus the growth of the valley is not the result of running water alone, though this is the most important single factor in the process.

If no further tributaries were developed, the valleys represented in Fig. 8 might, in the course of time, widen to such an extent as to nearly obliterate the intervening ridges. The surface, however, would not easily be reduced to perfect flatness. For a long time at least there would remain something of slope from the central axis of the former inter-stream ridge, toward the streams on either hand; but if the process of erosion went on for a sufficiently long period of time, the inter-stream ridge would be brought very low, and the result would be an essentially flat surface between the streams, much below the level of the old one. In this fashion, a series of rivers, operating for a sufficiently long period of time, might reduce even a high land mass to a low level, scarcely above the sea. The new level would be developed soonest near the sea, and the areas farthest from it would be the last—other things being equal—to be brought low. The time necessary for the development of such a surface is known as a *cycle of erosion*, and the resulting surface is a *base-level plain*, that is, a plain as near sea level as river erosion can bring it. At a stage preceding the base-level stage the surface would be a *peneplain*. A peneplain, therefore, is a surface which has been brought toward, but not to base-level.

The successive stages in the process of lowering a surface are suggested by Fig. 9, which represents a series of cross sections of a land mass in process of degradation. The uppermost section represents a level surface crossed by young valleys. The next lower represents the same surface at a later stage, when the valleys have grown larger, while the third and succeeding sections represent still later stages in the process of degradation.

If a land mass, including its marginal sea bottom, were to rise, the total area of land would be increased by the addition of a new marginal belt. If a series of rivers and valleys had been established before the rise, the streams, on reaching the borders of the new land, would find themselves at the ends of their valleys, and the water

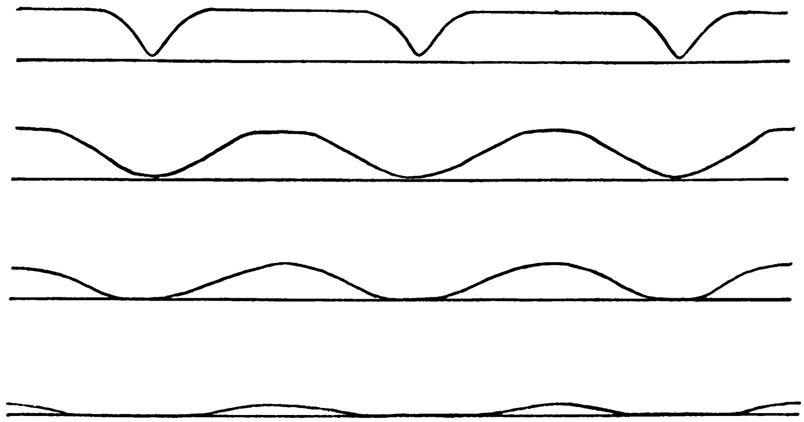

Fig. 9.
Successive profiles of a land surface developed during a cycle of erosion. Diagrammatic

would find its way thence to the sea by the lowest accessible line. Thus the stream (and presently the valley) would be lengthened at its lower end.

The first valleys which started on the land surface (see Fig. 8) would be almost sure to develop numerous tributaries. Into tributary valleys water would flow from their sides and from their heads, and as a result they would widen and deepen and lengthen just as their mains had done before them. By lengthening headward they would work back from their mains some part, or even all of the way across the divides separating the main valleys. By this process, the tributaries cut the divides between the main streams into shorter cross-ridges. With the development of tributary valleys there would be many lines

of drainage, instead of two, working at the area between two main streams. The result would be that the surface would be brought low much more rapidly, for it is clear that many valleys within the area between the main streams, widening at the same time, would diminish the aggregate area of the upland much more rapidly than two alone could do.

The same thing is made clear in another way. It will be seen (Figs. 10 and 11) that the tributaries would presently dissect an

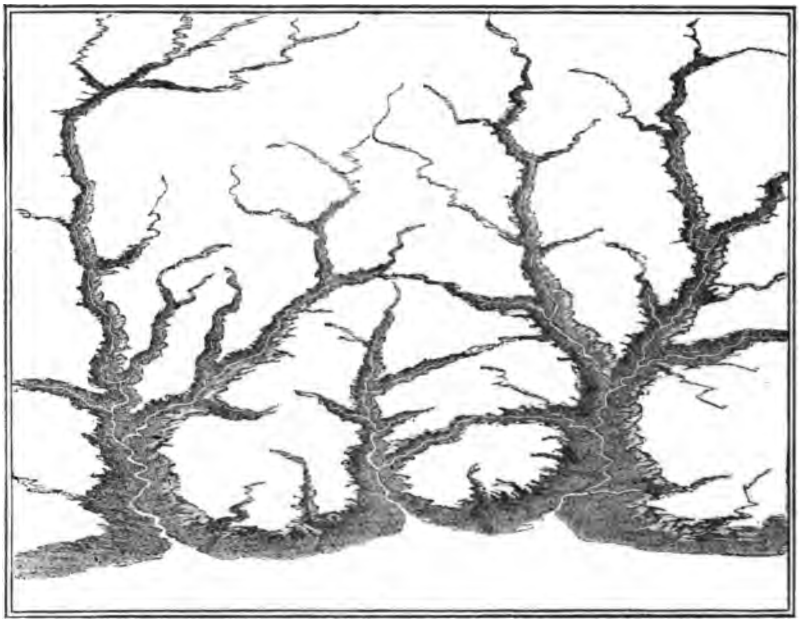

Fig. 10.

The same valleys as shown in Fig. 8, in a later stage of development. Their lower ends are represented as remaining constant in position, but they have been lengthened by head erosion and widened by wash from the sides.

area of uniform surface, tending to cut it into a series of short ridges or hills. In this way the amount of sloping surface is greatly increased, and as a result, every shower would have much more effect in washing loose materials down to lower levels, whence the streams could carry them to the sea. In process of time the result would be the same as in the case where there were no tributaries, but the plane (base-leveled) surface developed under these circumstances would be pro-

duced in a shorter space of time. Figs. 8, 10 and 11 represent successive stages of stream work in the general process of base-leveling.

So far, the matter seems simple. The process of erosion thus sketched would ultimately bring the surface of the land down to a new and lower level, and the last points to be reduced to this new and lower level in case the material of the land were homogeneous, would be the points most remote from the axes of the streams doing the work of leveling. But if the material of the land were of unequal hard-

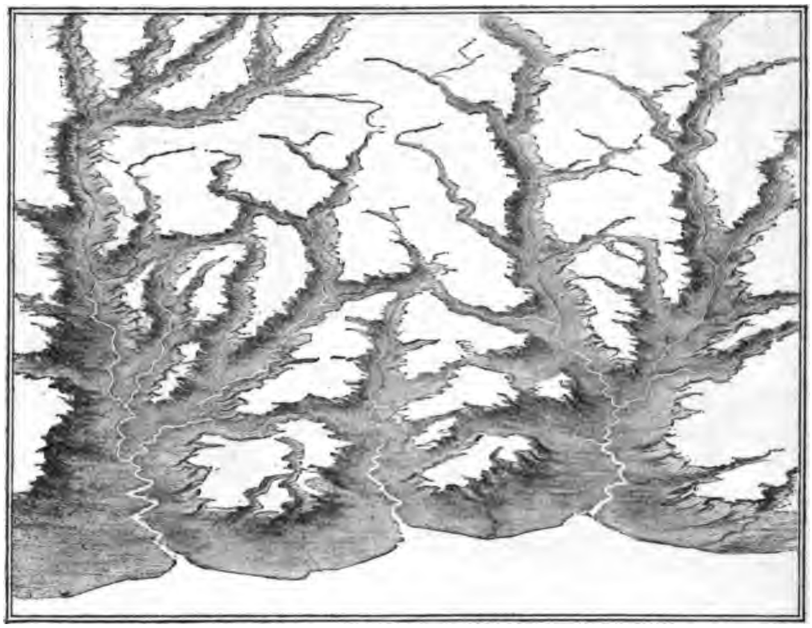

Fig. 11.

Same valleys as shown in Fig. 10, in a still later state of development. Compare with Figs. 8 and 10.

ness, those layers which were hardest would resist the action of erosion most effectively. The areas of softer rock would be brought low, and the outcrops of hard rock (*A*, Fig. 12) would determine the position of the ridges on the surface during all the later stages of a cycle. If there were bodies of hard rock, such as the trap rock in the Triassic formation, the shale on either hand would be worn down much more readily than the trap itself, and the latter would, at a certain stage in a cycle of erosion, stand out prominently. The Piedmont plain is in

just that stage of erosion in which the trap ridges are conspicuous (see relief map). The soft shale has been removed from about them, while they have suffered relatively little reduction in the present cycle. But if the time were sufficiently long, even these hard ridges would be demolished, for when the surrounding soft strata have been worn down as low as running water can wear them—that is, to base-level—the harder strata still stand at a level where surface-water can work effectively, even though slowly, upon them, and in spite of their great resistance they will ultimately be brought down to the common base-level. It will be seen that, from the standpoint of subaërial erosion, a base-level plain is the only land surface which is in a condition of approximate stability.

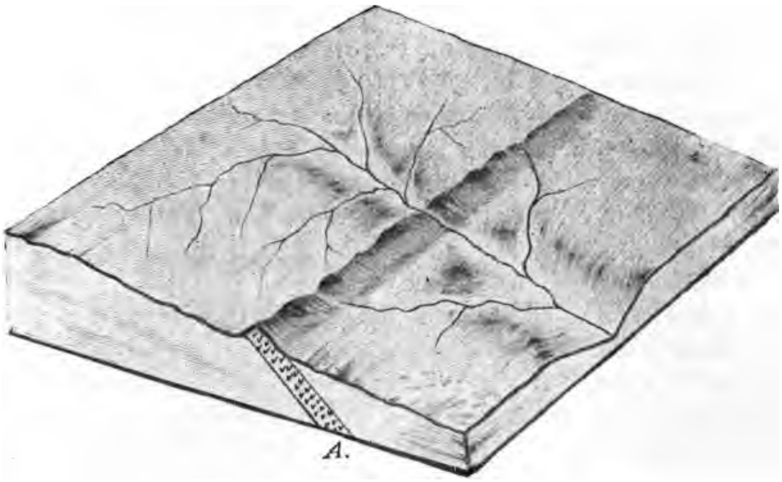

Fig. 12.
Diagram illustrating how a hard inclined layer of rock becomes a ridge in the process of degradation.

The processes of river erosion would not be essentially different in case the land mass upon which erosion operated were made up of tilted and folded strata. The folds would, at the outset, determine the position of the drainage, for the main streams would flow in the troughs or synclines between them. The streams, once developed, would lower their beds, widen their valleys, and lengthen their courses, and in the long process of time they would bring the area drained nearly to sea level, just as in the preceding case.

Such is the general process which is supposed to have been in operation in the subaërial development of a plane surface possessing the structure which affects northern New Jersey.

In regions of folded strata, certain beds are likely to be more resistant than others. When harder beds alternate with those less resistant, the former finally come to stand out as ridges, while the outcrop of the latter mark the sites of the valleys. The principal ridges of the Appalachians, as they now stand, are not the crests of folds, but the outcropping edges of hard layers of rock, from either side of which the less-resistant beds have been cut down to lower levels. Such are the Kittatinny and the Green Pond Mountain ranges. It follows that in a region of folded rocks, and in certain stages of a cycle of erosion, the ridges and valleys are likely to alternate with each other, each being continuous for a considerable distance. In an early stage of an erosion cycle, the edges of the hard layers would not have been isolated; in a very late stage the ridges would have been brought low; but at some intermediate stage (see Fig. 6) the ridge and valley type of topography would be pronounced, if there were considerable differences in the resisting power of the beds concerned. It is in this intermediate stage that the Appalachian mountain region finds itself to-day, after having been, in an earlier cycle, a base-leveled, or nearly base-leveled plain. This type of topography in the northwestern part of the State is illustrated both by the relief map and by the sections on Plate II. (p. 16).

It is important to notice that a plane surface (base-level) developed by streams could only be developed at levels but slightly above the sea, that is, at levels at which running water ceases to be an effective agent of erosion; for so long as a stream is actively deepening its valley, its tendency is to roughen the area which it drains, not to make it smooth. The Colorado river, flowing through high land, makes a deep gorge. All the streams of the high Western plateaus have deep valleys, and the manifest result of their action is to roughen the surface; but given time enough, and the streams will have cut their beds to very low gradients. Then, though deepening of the valleys will cease, widening will not, and inch by inch and shower by shower the elevated lands between the valleys will be reduced in area, and ultimately the whole will be brought down nearly to the level of the stream beds. This is illustrated by Fig. 9.

It is important to notice further that if the original surface on which erosion began is level, there is no stage intermediate between the beginning and the end of an erosion cycle, when the surface is again level, or nearly so, though in the stage of a cycle next preced-

ing the last—the peneplain stage—the surface approaches flatness. Indeed the base-level and the peneplain grade into each other. It is also important to notice that when streams have cut a land surface down to the level at which they cease to erode, that surface will still possess some slight slope, and that to the seaward. Along the coast, a base-level is at sea level. A little back from the coast it is slightly higher, and at a greater distance still higher.

No definite degree of slope can be fixed upon as marking a base-level. The angle of slope which would practically stop erosion in a region of slight rainfall might be great enough to allow of erosion if the precipitation were greater. All that can be said, therefore, is that the angle of slope must be low. The Mississippi has a fall of less than a foot per mile for some hundreds of miles above the Gulf. A small stream in a similar situation would have ceased to lower its channel before so low a gradient had been reached.

UNDERGROUND WATER.

In what has preceded, reference has been made only to the results accomplished by the run-off. The water which sinks beneath the surface is, however, of no small importance in reducing a land surface. The enormous amount of mineral matter in solution in spring-water bears witness to the efficiency of the work of the waters beneath the surface, for since the water did not contain the mineral matter when it entered the soil, it must have acquired it below the surface. By this means alone, areas of more soluble rock are lowered below those of less soluble rock. Furthermore, the water is still active as a solvent agent, after a surface has been reduced to so low a gradient that the run-off ceases to erode mechanically. It is reasonably certain that the solvent action of water has been an important factor in determining the relatively slight altitudes of the limestone areas in the northwestern part of the State.

CONCLUSION.

From the structure and topography of northern New Jersey, we conclude that a surface reproduced by filling the valleys would correspond with a surface which really existed at some time long antecedent to the present. From the structure of this plain we conclude that it was not formed by the simple elevation of sea bottom, bring-

ing it into the condition of land, but that it represents a truncated surface, which, but for the truncation, would have been much higher. From the approximate correspondence of adjacent elevations, we conclude that the truncated surface must have been reduced nearly to base-level. From the low elevations of hard rock which appear to have stood above the general level of this surface, we conclude that the area under consideration was not reduced to an absolute plain. From the relation it sustained to the sea, as well as from its present topography, we conclude that, at the time of its development, it had a slight southeasterly or seaward slope.

If the topography of the original surface from which a base-level has been developed was nearly plane, the topography of the base-level will be much like it, differing principally in being at a lesser altitude. The two surfaces will, however, be unlike in their drainage. A base-leveled surface, or a surface which approaches base-level, will be meandered by streams which had established their courses when the surface was higher, while a level or nearly level surface formed by uplift from the sea bed, would, at first, be without notable valleys or streams.

REJUVENATION OF STREAMS.

After the development of a base-level plain, its surface would suffer little change (except that effected by underground-water) so long as it maintained its position. But if, after its development, it were elevated, the old surface in a new position would be subject to a new series of changes identical in kind with those which had gone before. A base-leveled surface, meandered by sluggish streams, would, if elevated notably, be promptly altered. The elevation would give the established streams greater fall, and they would re-assume the characteristics of their youth. The greater fall would quicken their velocity; the increased velocity would be accompanied and followed by increased erosion; increased erosion would result in the deepening of the valleys; and the deepening of the valleys would lead to the roughening of the surface. But in the course of time, the *rejuvenated* streams would have cut their valleys as low as the new altitude of the land permitted, that is, to a new base-level. The process of deepening would then stop, and the limit of vertical relief which the streams were capable of developing would be attained. But the valleys would not stop widening when they stopped deepen-

ing, and as they widened, the intervening divides would become narrower, and ultimately lower. In the course of time they would be destroyed, giving rise to a new level surface much below the old one, but developed in the same position which the old one occupied when it originated; that is, a position but little above sea level.

If at some intermediate stage in the developm ent of a second base-level plain, say at a time when the streams, rejuvenated by the uplift, had brought half the elevated surface down to a new base-level, another uplift were to occur, the half completed cycle would be brought to an end and a new one begun. The streams would again be quickened, and as a result they would promptly cut new and deeper channels in the bottoms of the great valleys which had already been developed. The topographic forms which would result are suggested by the following diagram, which illustrates the profiles that would be

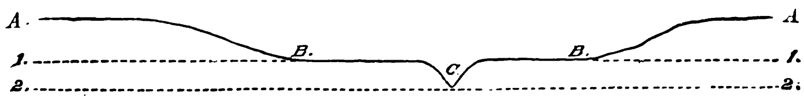

Fig. 13.
Diagram, cross-section of a valley, illustrating the topographic effect of rejuvenation by uplift.

found after the following sequence of events: 1°, The development of a base-level, *A A;* 2°, uplift, rejuvenation of the streams, and a new cycle of erosion half completed, the new base-level being at *B B* or 1–1; 3°, a second uplift, bringing the second (incomplete) cycle to a close, and by rejuvenating the streams, inaugurating the third cycle. As represented in the diagram, the third cycle has not progressed far, being represented only by the narrow valley, *C.* The base-level is now at 2–2, and the stream represented in the diagram has not yet reached it.

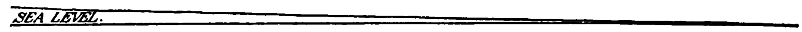

Fig. 14.
Profile of the valley of Cedar creek (Ocean county). Vertical scale, X 17.

The rejuvenation of a stream shows itself in another way. The normal profile of a valley bottom in a non-mountainous region is a gentle curve, concave upward. Such a profile is shown in Fig. 14, which represents the profile of the valley of Cedar creek.

Figure 15, on the other hand, is the profile of a rejuvenated stream, Wickeoheoke creek, tributary to the Delaware. This valley once had a profile similar to that shown in Fig. 14. Below *B*, its former continuation is marked by the dotted line *B C*. When the valley of Wickeoheoke creek had this profile, the Delaware flowed at the level

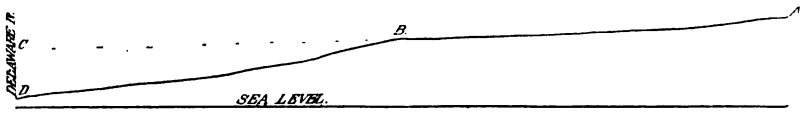

Fig. 15.
Profile of the valley of the Wickeoheoke creek (Hunterdon county), a rejuvenated stream. This earlier profile corresponded with that of the present time from *a* to *b*.

C, between 200 and 300 feet above its present channel. Uplift rejuvenated the Delaware and allowed it to deepen its valley to the level *D*. So soon as the valley of the Delaware was lowered at the mouth of the Wickeoheoke creek, the velocity of the latter was accelerated, and it at once began to lower its channel at this point. The lowering of its channel where it joins the Delaware quickened its velocity just above. Thus the point of the valley which was most affected by the

Fig. 16.
Cross-section of the Wickeoheoke valley above the point *B* (Fig. 15). Vertical scale, X 17.

increase of velocity was transferred step by step up stream, and the point *B* marks the point to which it has advanced. The Wickeoheoke therefore flows in a valley which belongs to two cycles. From *A* to *B* the valley is broad, shallow and old, and was developed in a cycle earlier than the present. From *B* to *D* the creek flows in a newer valley, excavated in the bottom of the old one in a later cycle.

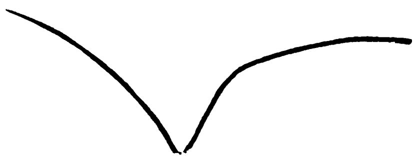

Fig. 17.
Cross-section of the Wickeoheoke valley below the point *b*, showing the effects of a rejuvenation. It will be seen that there is here a new and rather narrow valley in the bottom of an old and wide one. Vertical scale, X 17.

The cross-sections of the valley, as shown by Figs. 16 and 17, correspond with this interpretation. The first of these figures represents a cross-section of the valley above *B*, and the second a cross-section below that point.

SECTION II.

THE KITTATINNY BASE-LEVEL OR SCHOOLEY PENEPLAIN.

The preceding sketch gives the general principles on which the history of the topography of northern New Jersey appears to be based. After the rocks had been formed, they were elevated above the sea to some undetermined but great height, being in places, at least, much folded. The elevation which preceded the development of the peneplain took place at the same time that the body of the Appalachian system was brought out of the sea, and its strata folded and uplifted into mountains. This was at the close of the Paleozoic era. The elevation was probably gradual, perhaps so gradual as not to involve sensible changes of surface in any limited period of time. The erosion processes began their work upon the land so soon as it appeared, but apparently did not keep pace with the elevation. After a certain stage of elevation had been reached, the uplift seems to have ceased, and the land to have stood without great change of level for a long period of time. During this time, the rivers which had been gradually developing on the surface while it was being uplifted, cut their valleys as low as running water could wear them, and the tributary valleys followed the example of their mains. When their limits in depth were reached, the widening of the valleys continued, until all of northern New Jersey, as well as the territory both north and west of it, was reduced nearly to a base-level but slightly above the sea. This plain doubtless had a gentle slope to the southeast, since that is the direction in which the drainage appears to have discharged. The plain was reduced most nearly to base-level near the sea, and departed more widely from it farther inland. Indeed, toward the sea it was a base-level, while remote from it the surface was only a peneplain. It is not now possible to estimate even approximately the thicknesses of the rocks which were removed during the development of this surface, but it is safe to say that they are to be reckoned by thousands, rather than by hundreds of feet.

It is equally impossible to define the exact extent of land within the State of New Jersey while this peneplain was developing. The

crests of Schooley's mountain and First mountain represent the old peneplain surface. The general slope from Schooley's mountain to First mountain, along a northwest-southeast line, is about thirty-five feet per mile. Continued to the southeast, this slope would reach sea level about the head of Raritan bay. By similar calculations along a line farther west, the present slope of the old surface would reach sea level somewhat below Trenton; but it is not certain that the present slope corresponds with that which existed at the time of the development of the peneplain. Indeed, it is probable that it does not; yet, so far as present knowledge goes, it seems likely that during the development of the peneplain the southern part of the State was largely beneath the sea. If the area submerged at this time be thought of as including most of the Coastal plain, the conception will probably not be far from the truth.

The development of the peneplain followed the uplift of the Appalachians, and was, therefore, post-Paleozoic. Since the Triassic strata were involved, it must have been post-Triassic. Early in the Cretaceous period, the southeastern edge of this erosion plain sank a little, allowing the sea to come in over it and to cover it with a new series of sedimentary beds. This part of the plain was pre-Cretaceous. The surface of the plain, so far as submerged, seems to have been reduced essentially to flatness. It was a base-leveled rather than a peneplained surface. Farther from the sea, the surface was doubtless higher and less completely reduced, and throughout the Highlands, erosion appears to have been going on while the Cretaceous beds were being laid down. In the belief that this was true, Davis * long since regarded the plain as having reached its most perfect development in the Cretaceous period, and so has called it the Cretaceous peneplain.†

The Kittatinny mountain, the crests of the main mass of the Highlands, the crests of the Watchung and Sourland mountains, the surface of the Hunterdon plateau, and the crest of the Rocky Hill range, represent remnants of the oldest peneplain (or base-level) of which

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* "Geographic Development of Northern New Jersey," Davis and Wood, Proc. Bos. Soc. Nat. Hist., Vol. XXIV.

† If the recent position of Marsh be confirmed (Am. Jour. Sci., Dec., 1896), making the beds of New Jersey which have heretofore been regarded as early Cretaceous, Jurassic, the southeastern part of the base level would appear to have been essentially completed still earlier; but against the position of Marsh, physical geology seems to offer insuperable difficulties.

SECTION III.

THE CRETACEOUS DEPRESSION.

After the Schooley peneplain had reached an advanced stage of development, its southeastern portion, which had reached the stage of a base-level plain, was depressed, allowing water to stand upon its surface.* Whether that part of the plain which was not submerged sank, stood still, or rose is not now known. While the water stood over the submerged southeastern margin of the plain, the Cretaceous formations were deposited upon it. How far to the north the sea transgressed the former land surface is not known, but the remnants of the Cretaceous beds in the vicinity of Sand Hills, north of Monmouth Junction, show that the northward extension of the Cretaceous beyond its present outcrop was considerable. The base of the Cretaceous here is a little less than 200 feet above tide, and the top of that part which remains has an elevation of about 300 feet. It is hardly probable that the top of the formation as it now stands represents its original summit, for erosion must surely have removed something from its upper surface. It is, therefore, probable that at least all the surface of the central part of the State which now stands at a level as low as 300 feet was covered by the Cretaceous, and it may have extended much farther north. Davis long since advocated the view that some formation now removed by erosion once extended over the southeastern part of the Schooley peneplain, reaching much farther north than the line indicated. It was supposed by him that this formation was the Cretaceous, for he says † that the Crecateous completely covered the Triassic formation "in the middle and southwest side of the State." There is now reason to believe that a younger formation, probably the Miocene (or Beacon Hill) extended farther north than the Cretaceous, or, at any rate, that such a formation extended far north later than the Cretaceous. So far as the arguments which Davis advances are concerned, the younger formation which covered the edge of the old peneplain might as well have been Miocene

* The oldest Cretaceous beds, the Raritan, are not believed to be of marine origin. They, nevertheless, denote a sinking of the bed on which they rest.

† Loc. cit., p. 402.

as Cretaceous. When Davis wrote, the former northern extension of any formation younger than the Cretaceous was not known.

It seems very doubtful whether either the Cretaceous or Miocene, or any other formation younger than the Trias, ever covered the Hunterdon plateau, for this plateau seems to represent the surface of the Schooley peneplain, and to have suffered little erosion since. Had the Cretaceous, or any younger formation, ever crossed it, the complete removal of this younger formation (for no trace of it now remains) would hardly have left so plane a surface *at the old peneplain level.* Davis' argument for a former covering on this part of the Trias, is based on the courses of certain streams. His argument, while plausible, is not altogether conclusive, and seems not to have sufficient force to outweigh the considerations on the other side.

While the southeastern base-leveled border of the peneplain was submerged, the Cretaceous beds were deposited on its surface. The sediments seem to have been derived from the northwest, from which it is inferred that the area draining in this direction had not all been reduced to a base-level During the submergence of the coastal part of the peneplain (base-level), therefore, the more inland portion was still being degraded.

SECTION IV.

POST-CRETACEOUS UPLIFT.

THE BEGINNING OF THE SECOND CYCLE OF EROSION.

Later, a movement in the opposite direction set in, and that part of the old plain which had been submerged and covered by the Cretaceous was lifted above the sea, while that part which had not been submerged was lifted to a position much higher than that which it had previously occupied. The seaward slope of surface of the old Schooley plain, as measured by its remaining crests, is rather more than a peneplain which so closely approached a base-level would be likely to possess. From this it is inferred that the peneplain has been tilted seaward since its development. It is not certainly known whether the tilting took place during the uplift which followed the deposition of the Cretaceous beds or at a later time, but it is at least possible and perhaps probable that, as the uplift took place, the northwestern portion of the State was lifted more than regions farther to the southeast, tilting the peneplain seaward at the same time that its average elevation was increased. Not only this, but there is some reason for believing that its southeastern margin suffered deformation (unequal uplift). Russell * has pointed out that the trap of the Palisade ridge is probably continuous beneath the surface with that of the Rocky Hill range. Davis † has subscribed to this view, and Kümmel thinks it probable.

In support of the position that the Palisade ridge and the east end of the Rocky Hill range are parts of one trap sheet the middle portion of which is now buried, stands the patent fact that the Palisade ridge declines notably and regularly to the south, toward the interruption, while the Rocky Hill range declines (though less notably) to the east, likewise in the direction of the break. Again, between the ends of the ridges, as they now appear, there are some small outcrops of trap, at low levels, which may represent the crest of the buried trap sheet. If the two ridges be parts of one trap sheet, the apparent

* Annals of the New York Academy of Science, Vol. I., 1878, p. 241.
† Loc. cit.

break in the continuity between the south end of the Palisade ridge and the east end of the Rocky Hill range may be the result of the lesser uplift in that section as compared with that to the north and west. This differential movement may have begun in the sinking which preceded the uplift, so that the part of the trap sheet which does not now appear, was more deeply buried during Cretaceous time than that which is exposed.

As the peneplain and its submerged seaward border were elevated, the uplifted surface consisted of two distinct portions—1°, the part which had not been submerged, and, 2°, the part over which the Cretaceous beds had been laid down. On the former there were already streams and valleys, the streams being sluggish and the valleys shallow; on the latter, as it emerged, there were no valleys or streams. As that portion which had not been submerged was lifted up, the streams which had meandered slowly across it near their base-level became more active, and began to cut their channels deeper.

It is probable that these streams were located on the softer formations as distinct from the harder, for in the course of their development streams tend to shift their channels to such positions. Thus, in Sussex county a stream probably followed the present course of the Delaware, while others flowed through Kittatinny valley, and still others occupied the sites of the Musconetcong and Pohatcong. The Kittatinny mountain and other belts of hard rock formed the low divides, for such belts had probably not been brought so low as their surroundings during the development of the peneplain.

The uplift brought the preceding (the Schooley peneplain) cycle of erosion to a close, rejuvenated the streams, and inaugurated a new cycle. With the elevation, the process of erosion started over again, much as in the first cycle, except that the streams were now organized and adjusted to the rock structures over which they flowed, whereas in the first cycle the development of the streams was the first step in the process of base-leveling.

It was at this time that all the streams of the northern part of the State began to sink their valleys into the Schooley peneplain. It was at this time that the Delaware began the long task of excavating the great depression which now lies at the western base of the Kittatinny mountain; that the streams of the Kittatinny valley began to work out the great trough which now separates the Highlands from the Kittatinny crest to the west, carrying the material which filled it to

the sea; that the Musconetcong and Pohatcong rivers began the excavation of their present valleys, and that the streams of the Highlands began their more difficult task of lowering their valleys through rock which was more resistant.

The changes in surface accomplished in the period of erosion which immediately followed the uplift of the Cretaceous, cannot now be distinguished from those which took place at a later time. It seems probable that the period of erosion following the Cretaceous uplift was long, but that the surface of the State stood so low that the rate of erosion was slow, and that, as a result, great changes were not wrought.

As that part of the former peneplain (base-level) which had been covered by the Cretaceous came up out of the sea, it possessed no valleys. The valleys which had been developed upon it in its earlier history had been obliterated by the deposits made during the Cretaceous submergence. When the streams descending from the older formations to the northwest reached the area covered by the Cretaceous beds, their waters were therefore obliged to choose new paths to the sea across the nearly emerged surface. Their courses were determined by such inequalities of slope as the new surface possessed.

The streams which flowed to the sea from the elevated peneplain, therefore, had two portions—an upper, flowing in old valleys, and a lower, making new valleys across the Cretaceous beds. The areal extent of the territory brought out of the sea at this time is not known, but it is probable that half the Coastal plain at least was brought above the sea, so that the streams were greatly lengthened at their lower ends.

In so far as there was a border of Triassic rock between the Highlands and the Cretaceous, not covered by the latter, it was crossed by the streams from the Highlands. On the whole, these beds yielded to erosion more readily than the harder rocks of the north and northwest, and less readily than the softer rocks to the south and southeast. The extent of the erosion accomplished at this time in this area is not known, since it has not been discriminated from that which followed.

On that part of the present Triassic plain which had been covered by the Cretaceous, and which was, at the close of the Cretaceous, brought above sea level, the streams were likewise active. Here, because of the less-resistant rock over which they flowed, the chances

were, so far forth, favorable for their rapid cutting. On the other hand, the altitudes appear to have been so slight that the streams had not great velocity, and hence did not develop great valleys. Whatever valleys the streams excavated at this time in that part of the Triassic plain which had been covered by the Cretaceous, were subsequently filled, and need not be here discussed.

Over all the land area south of the present Piedmont plain, that is, over all that part of the Coastal plain which was at that time land, valleys were in process of development. Many minor streams of which there now remains no record were doubtless in existence, draining the land area covered by the Cretaceous beds. These minor streams were in part tributaries of the larger ones flowing down from the older formations to the north, and in part independent streams, developed *de novo* on the Cretaceous surface as it emerged from beneath the sea.

These suggestions as to the drainage of the Cretaceous area, in the post-Cretaceous period of erosion, are based on general principles, not on the record of fact, for the facts are not now to be had. Had the land surface remained permanently above the water from that time to the present, the history of the topography would be more simple; but such is not the fact. All that can be said of the erosion which immediately followed the uplift of the Cretaceous beds, is that the streams were everywhere active, and that they everywhere developed valleys of such size as the elevation of the land, the character of the rock, and the duration of the period made possible.

SECTION V.

THE MIOCENE SINKING.

After a long period of erosion, lasting, so far as the northern half * of the State is concerned, at least through the Eocene period of geological history, the southern portion of the area which had been land again sank, letting the sea in over considerable areas which had been above its level.

During this submergence the old land surface, now below the water, was mantled by a new formation which filled the depressions and obliterated the irregularities which the post-Cretaceous streams had made, just as the Cretaceous beds had previously obliterated the unevennesses of the surface on which they were laid down.

The formation (or formations) deposited during this submergence has been discussed in the Annual Reports of recent years, under the name of Beacon Hill, and has been referred tentatively to the Miocene. It seems possible, however, that the Miocene and Beacon Hill are separable. If not, the latter represents the last stage of the former. So far as the topographic history of the State is concerned, the geological relations of the Beacon Hill and Miocene do not appear to be of importance, and they will here be spoken of as one formation.

The Beacon Hill formation was deposited in considerable part on a surface which had once been land, and which had been subject to erosion throughout the long period of time which had elapsed since its emergence from the sea, at the close of the Cretaceous. As already indicated, it is not now possible to say how much erosion it had suffered; but its long exposure as a land surface must have resulted in much erosion wherever it was sufficiently high to allow running water to operate effectively.

Erosion was probably considerable along the northern portion of the area which the Cretaceous originally covered, and in the territory to the northwest, but it is far from certain that the Cretaceous surface of that part of the Coastal plain now covered by the Beacon Hill formation was deeply eroded before the deposition of the latter. The

* Eocene beds in the Coastal plain show that some parts of this plain were below sea level during some (the early) part of the Eocene.

base on which the Miocene rests appears to be nearly plane. Its plainness may be due, so far as now known, either, 1°, to its failure to be roughened while it was land (because it was too low), or, 2°, to its having been base-leveled; but, in the light of present knowledge, the former seems more probable than the latter.

The submergence which preceded the deposition of the Beacon Hill formation was extensive, letting the sea in over all the area then covered by the Cretaceous, and over most if not all of the Trias from which the Cretaceous had been removed during the post-Cretaceous erosion interval. The Beacon Hill formation may have extended even farther north than the Cretaceous had done, and quite certainly farther north than the Cretaceous did at the time of the deposition of the younger formation. It probably covered the Watchung mountains as far north as the Passaic, the Sourland Mountain plateau, and reached to the base of the Hunterdon plateau. From Pattenburg to Pompton the Beacon Hill may have covered all the Trias, even reaching and perhaps crossing the margin of the Highlands (crystalline schists) at some points between High Bridge and Bernardsville. The same formation covered the southern part of the Palisade ridge, if not the northern, and all of Staten Island. The map, Plate IX. (p. 93), gives some idea of the extent of the maximum submergence during the period when the Beacon Hill formation was deposited.

After the deposition of the Beacon Hill formation, the area over which it had been spread was again elevated, and the history of the topography of all that part of the State which was covered by the formation, so far as it can now be read, dates from this re-emergence of the surface covered by the Beacon Hill formation.

SECTION VI.

THE POST-MIOCENE (BEACON HILL) UPLIFT—THE PRE-PENSAUKEN CYCLE OF EROSION.

A. IN THE APPALACHIAN ZONE.

In the northern part of the State, not covered by either the Cretaceous or Beacon Hill formations, erosion may have gone on continuously from the time of the post-Cretaceous uplift to the time of the uplift which brought the Beacon Hill formation above the water. If that part of the State which was not submerged when the Beacon Hill formation was depositing, partook of the downward movement which brought the larger part of the State below the sea, erosion in the former may have been checked, so long as the depression lasted; but of this there is no topographic record, or at least none which has been made out. The excavation of the great valleys of the northern part of the State began with the post-Cretaceous uplift, and continued long after the uplift which brought the Beacon Hill formation into the position where it was subject to river erosion. From evidence furnished by the northern part of the State, it is not now possible to say whether the larger share of the excavation is to be assigned to the time before or the time following the deposition of the Beacon Hill formation, but the phenomena of the region farther south point to the conclusion that the larger part of the post-Cretaceous erosion followed the deposition of the Beacon Hill formation. Since the erosion accomplished between the deposition of the Cretaceous and Beacon Hill formations cannot be distinguished, in this zone, from that which followed the deposition and uplift of the latter, the results of both will be regarded as parts of one cycle.

To this cycle belongs the excavation of the great Kittatinny valley. During this long interval of erosion, lasting from the close of the Cretaceous to post-Miocene time, the streams flowing over the relatively soft strata of this valley appear to have lowered their courses essentially to a new base-level accordant with the new position of the land. After having attained this depth, the valleys appear to have been widened, until a broad plain, ten to twelve miles wide and 500 to 600 feet below the Kittatinny crest, had been developed. This new plain is now represented by the crests of the low ridges in the Kittatinny valley—crests which rise 900 to 1,000 feet above the sea, as

the land now stands. An idea of the surface of the Kittatinny valley, as it was at the close of the cycle now under consideration, may be obtained by supposing the sub-valleys of the great valley to be filled up to the levels of the intermediate ridges. These sub-valleys are of later origin, and belong to a later cycle. Fig. 18 represents the cross-section of the valley as it is now (full line), and as it is believed to have been when its broad bottom was first developed as a plain (dotted line).

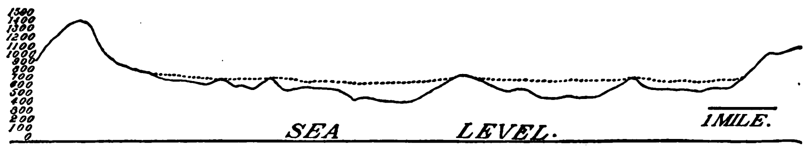


Fig. 18.

Cross-section of Kittatinny valley as it now is (full line), and as it was at the close of the pre-Pensauken erosion cycle (dotted line).

While the Kittatinny valley was being excavated, the Delaware valley was being enlarged by the stream which flowed through it. The eastern border of the valley then excavated reached the western base of the Kittatinny mountain. The tops of Wallpack and Hog Back ridges, corresponding in level with the Kittatinny valley as it then was, represent the valley plain of the Delaware at this stage. The Flatbrook and Millbrook valleys between these ridges and the Kittatinny mountain are of later origin, corresponding with the sub-valleys of the great valley on the east side of the Kittatinny range.

The excavation of the Kittatinny valley, on the one hand, and of the Delaware on the other, left the Kittatinny range between. This range, the axis of which is the Oneida conglomerate, came to be a ridge or mountain because of its superior power of resistance. The general principles involved in its isolation are the same as those involved in the isolation of the trap ridges (see Fig. 12). The higher inclination of the strata, in the case of the Kittatinny mountain, gives the ridge steeper slopes, and the greater altitude of the region where it occurs, accounts for its greater elevation.

The superior hardness of the Oneida caused it to become a divide at an early stage in this cycle. As a result, the tributaries to the Delaware from the east were small, and made little headway in this obdurate rock. The streams which flowed down the east slope of the range to the Kittatinny valley were likewise small, and during the whole of the long period of time involved in the development of the broad Kittatinny valley, 600 feet below the crest of the range,

they did nothing more than develop narrow, gorge-like valleys in the mountain, which merely notched its crest. Even the Delaware, considerable stream as it was, made but a narrow valley, a part of the Water Gap, through the Kittatinny range during this time.

Culver's gap, and the lesser gap near Catfish pond, probably had their beginning before this time. They were probably occupied by streams in the Schooley cycle, and these streams held their courses sufficiently long in the succeeding cycle to cut the gaps to their present depths. The process by which the streams abandoned their courses, leaving their former valleys through the range wind gaps, is

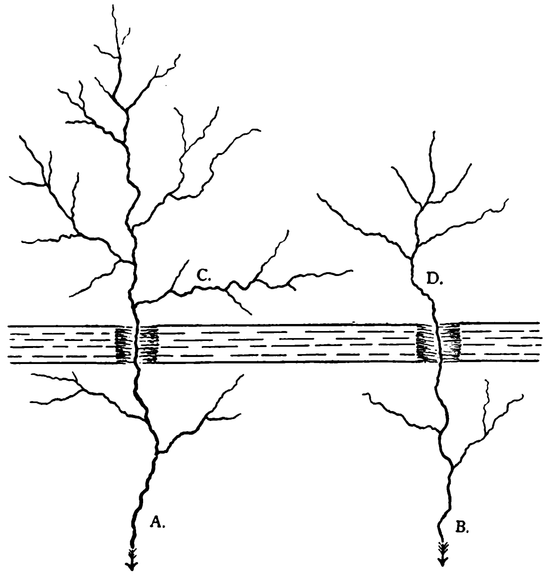


Fig. 19.
Diagram illustrating a condition of drainage favorable for the development of a wind gap.

illustrated by Figs. 19 and 20. In the first of these figures, two streams are represented as crossing the outcrop of a hard layer of rock. Both have cut gorges through it, but the gorge of *A* is greater than that of *B*. The tributary *C* is, therefore, in a position favorable for development, and its head may work back so as to tap the stream *B* at *D*. The result is represented in Fig. 20. The gorge formerly occupied by *B* is no longer occupied by a stream, and has become a wind gap.

At the same time that the Delaware and the streams of the Kittatinny valley were doing the work indicated, the Musconetcong and Pohatcong valleys were likewise in process of excavation, and reached

stages comparable with that of the Kittatinny. Both developed plains of some width, and at levels somewhat lower than that of the Kittatinny valley, as the streams which excavated them were nearer the sea. In the vicinity of Washington, the plains then developed in the two valleys were at a level which is now 400 or 500 feet above the sea. Near Hackettstown, farther up the Musconetcong, the corresponding plain is about 600 feet above tide.

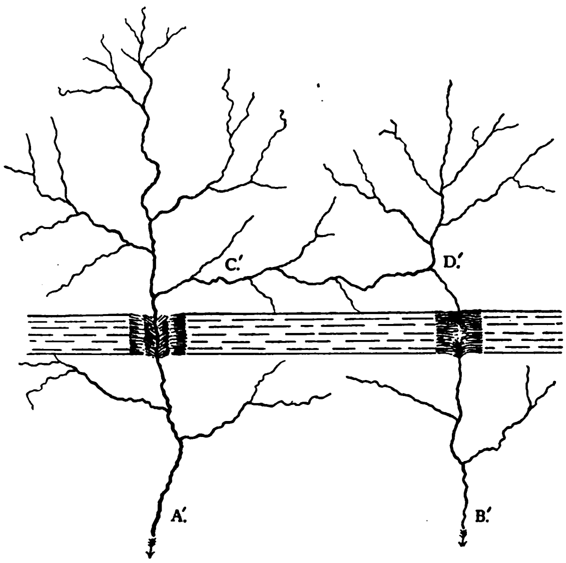


Fig. 20.

Diagram illustrating the development of a wind gap from the condition of drainage represented in Fig. 19. The wind gap is below *D'*, where the stream *B'* (Fig. 19) formerly crossed the hard layer.

B. IN THE HIGHLANDS.

The Pequannock, Rockaway and Wanaque rivers, crossing the harder crystalline schists, excavated their valleys less rapidly than the rivers of the Appalachian zone. On the other hand, the schists were less resistant than the Oneida conglomerate of the Kittatinny range, and these streams were therefore able to open wider valleys than the Delaware where it crossed the Kittatinny mountain. Where the streams of the Highlands, like the South Branch of the Raritan from Califon to Naughright, had courses along the outcrop of a belt of softer rock, their valleys became more capacious. But the valley of the South Branch was retarded in its development, even where the rock was easily eroded, by the fact that the stream, after

crossing the rock which was an easy prey to erosion, was obliged to cross a stretch of obdurate rock—between Califon and High Bridge. The valley above, no matter how easily the rock was eroded, could not be cut below the level of the resistant rock farther down the stream. The resistant rock below Califon, therefore, limited the depth of the valley above.

It was at this time that the remarkable High Bridge-Greenwood Lake valley (see page 23) was chiefly developed. The Pequannock seems to have held its present course throughout the cycle, developing the valley which it now occupies, while some of its tributaries, much smaller than itself, but flowing on softer rock, opened valleys which were more capacious, though not deeper. This was especially true in the region south of Newfoundland. The principles involved are illustrated by the following figure.

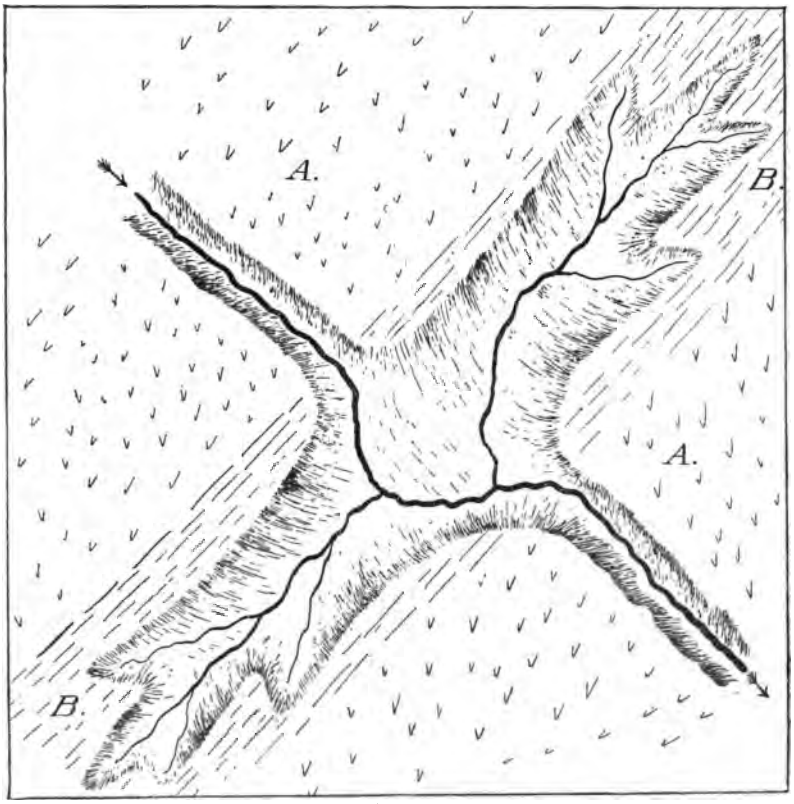


Fig. 21.

Diagram illustrating conditions under which tributaries may come to have valleys much wider than that of their main, where the rock is of unequal hardness. The rock represented by *A A* is harder, and that within the area *B B* softer.

C. ON THE PIEDMONT PLAIN.

Outside the Highlands, on the Piedmont plain to the southeast, the streams found less resistance to their work of degradation. Much of the Triassic formation base-leveled in the previous cycle had been covered by the Cretaceous beds. The formations of this period probably extended as far north as the Sourland and Watchung mountains, and possibly still farther. It probably did not reach the border of the Highlands in the western or in the northern part of the State, and there is no conclusive evidence that it did so at any point. The Cretaceous beds covering the Trias were soft, largely unindurated, and in the erosion interval which followed the uplift of the Cretaceous, the streams flowing out from the Highlands doubtless cut down their channels with ease to such depths in the Cretaceous as the altitude of the land permitted. Then came the submergence which allowed the deposition of the Beacon Hill formation, and this in turn was followed by the uplift which brought the new formation above the sea.

Since the Triassic formation is believed not to have been completely covered by the Beacon Hill formation, some of the streams, as they emerged from the Highlands on the north after the uplift following the deposition of this formation, flowed over, 1°, a stretch of Triassic rock, and then, 2°, over a surface which was covered with the Beacon Hill formation. Through the Highlands and to the border of the newly-emerged formation they occupied established valleys, but below that border they were obliged to choose new courses across the featureless plain.

During the period of erosion which followed the Cretaceous uplift, the great valley between the Palisade ridge and First mountain was probably begun through the agency of the southward-flowing drainage. During this time, also, it is probable that the area of soft shale enclosed by the hard Watchung mountains on the east and the Highlands on the west, was being lowered by streams which had no more than narrow valleys where they crossed the hard trap ridges of First and Second mountains on their way to the sea. During this time, also, the North and South Branches of the Raritan were doubtless making for themselves considerable valleys in the Triassic and Cretaceous beds which they crossed after leaving the Highlands, while lesser streams, flowing toward the Delaware in western Hunterdon

county, were developing valleys on that part of the Trias which had probably not been covered by the Cretaceous.

However great the depressions 1°, between the Palisade ridge and First mountain, 2°, between Second mountain and the Highlands, and 3°, along the branches of the Raritan, had become before the Miocene-Beacon Hill submergence, they were filled, or largely filled, with the formation then deposited. When the surface emerged after the deposition of that formation, the streams, undaunted by the obliteration of their previous work, attacked the new surface with all the vigor of youth.

On reaching the margin of the recently-emerged Beacon Hill formation, the streams flowing out from the Highlands on the north found their way across it as best they might, cutting valleys in it just as they had in the Cretaceous before. New streams and valleys also came into existence on the new land surface, developing just as streams and valleys normally do. From this time on, the erosion history is relatively clear. Both the new valleys and the lower extensions of the old ones were dependent for their position on the slopes of the surface. Both were therefore *consequent* streams.

Plate X. shows the drainage of that part of the State which was covered by the Beacon Hill formation as it is conceived to have established itself after the uplift which inaugurated the post-Beacon Hill (pre-Pensauken) cycle of erosion. The drainage shown on the map is, in some of its details, more or less hypothetical, but of its general correctness there can be little doubt. It will be seen that the course of the drainage was different, in some important respects, from that which now obtains.

The surface covered by the Beacon Hill formation may be divided for convenience into two parts—1°, the area where the indurated Triassic formation (shale, sandstone, trap, etc.) beneath was well above sea level after the subsequent uplift; and 2°, the area where no indurated formation rose sufficiently high to be reached by stream erosion. The first of these areas lay to the north, the second to the south, their line of junction corresponding approximately with the Fall line (see p. 5) which separates the Piedmont plain from the Coastal plain. While erosion was going on in both these regions, after the uplift of the surface covered by the Beacon Hill formation, the resultant phenomena were different. In the former, the streams, after cutting through the soft Beacon Hill beds, found themselves flowing on the harder Triassic rock, while in the latter they continued, to the end of their history, to

PLATE X.

EXPLANATION OF PLATE X.

This plate shows the drainage as it is believed to have established itself on the surface of the Beacon Hill formation. The original limit of the Beacon Hill formation to the northwest is suggested by the line *C E* or *C D*, to the northwest of which the streams are represented by dotted lines. Their courses on the Beacon Hill formation are represented by full lines. The shaded part of the map represents the area which was brought nearly to base-level during this (the pre-Pensauken) erosion cycle.

B. H. = Beacon Hill. A. H. = Atlantic Highlands.

work in formations which were mainly not indurated. This distinction is to be looked upon as no more than a general one, for the Cretaceous beds beneath the Beacon Hill formation were not altogether homogeneous, and some layers were measurably resistant.

In both regions, the positions of the streams, as they established themselves on the surface of the Beacon Hill formation, were dependent on the slope of the surface. But where the Triassic beds beneath the Beacon Hill formation were well above sea level, the streams, in course of time, cut through the upper formation into the Trias beneath.

The surfaee of the Trias thus reached by the streams, may itself be divided into two parts—(*a*) that where no Cretaceous intervened between the Beacon Hill and the Trias, and (*b*) that where Cretaceous beds still remained. The Triassic surface on which the Cretaceous was deposited, appears to have been nearly smooth (base-leveled) when the deposition took place, so that in the latter of the two cases mentioned above, the Triassic surface reached by the streams was

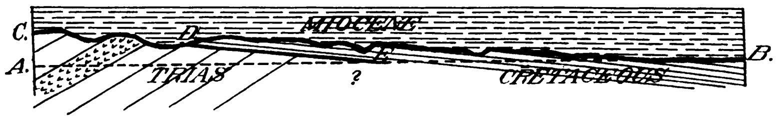


Fig. 22.
Illustrating the stratigraphic conditions referred to in the accompanying text.
A B = Sea level.

nearly plane. On the other hand, the surface of the Trias from which the Cretaceous had been removed before the deposition of the Beacon Hill formation (*C D*), may have been marked by more considerable valleys and inter-valley divides. There is little evidence, however, that the surface had been greatly roughened by erosion in the post-Cretaceous-pre-Beacon Hill erosion period. The whole series of relationships here referred to are expressed diagrammatically in Fig. 22.

Had the streams of the cycle of erosion which began with the uplift of the Beacon Hill formation, corresponded in position with those of the post-Cretaceous erosion period, the streams of the former would have occupied the old valleys of the latter, when they had cut down to the proper level. But the streams established themselves on the Beacon Hill surface according to its slopes, and in complete disregard of buried valleys beneath, except in so far as they influenced

the topography of the surface. As a result, it sometimes happened that a stream, after cutting through the Beacon Hill formation, found itself flowing on the Triassic surface in complete disregard of the topography which had been developed at an earlier time. Such streams are said to be *superimposed*.

Where the underlying surface of the Trias was nearly smooth, it was sometimes composed of rock of unequal hardness. Thus, in the Cretaceous erosion cycle, the region about Rocky hill appears to have been reduced nearly to base-level, the interval of erosion having been long enough to reduce the trap and the Lockatong shales, hard as they are, to about the same level as the softer Brunswick shales* about them. The Cretaceous beds which had covered this region had not been removed at the time of the deposition of the Beacon Hill formation. When the streams which took their courses on the latter had cut through the upper formations, they found themselves flowing across the surface of the Trias without regard to hard and soft layers. In such cases, also, the streams are said to be superimposed. In the one case they flowed on the discovered formation in disregard of its *topography* and structure, and in the other in disregard of its *structure* only (see Figs. 23 and 24).

A long series of changes in the courses of the streams must have followed their discovery of the Triassic beds beneath the softer beds above. These changes resulted in the *adjustment*, or partial adjustment, of the streams to the structure and topography of the formation on which they found themselves. Adjustment on the part of streams consists primarily in—1°, the shifting of their courses so as to avoid, so far as possible, hard layers; and 2°, the shifting of their courses so as to flow, so far as possible, along the strike of the strata. This tendency to flow along the strike is especially marked where the strata are of unequal hardness. The methods by which these adjustments take place are somewhat complex, but they are based on very simple principles, the most important of which is that softer rocks erode more rapidly than harder ones. It was adjustment which robbed Culver's gap of the stream that made it, changing it from a water gap to a wind gap; that is, to a gap through which water does not flow. Further illustrations of adjustment which took place at this time will be noted farther on.

There may have been streams superimposed on the Trias, where Cretaceous beds intervened between it and the Miocene; but since

* Kümmel, Annual Report for 1896.

the inequality in hardness between the Beacon Hill formation and the Cretaceous was not great, the topography and structure of the lower of these formations (the Cretaceous) did not affect the courses of the streams to the same extent as the topography and structure of the Trias.

In the region where the Triassic surface beneath the Beacon Hill formation was not above sea level, or so little above it as not to be reached by the cutting streams, there was less inequality of hardness to cause the streams to shift their courses. Yet the Cretaceous beds

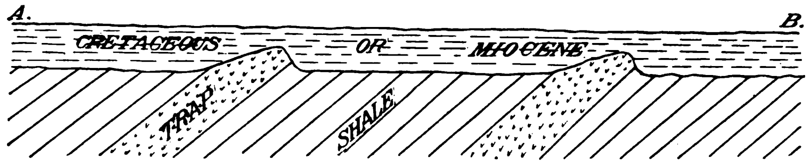


Fig. 23.
Diagram illustrating superimposition of streams. A stream flowing in the direction *A B* has a course in disregard of both topography and structure.

are by no means uniform, and their heterogeneity is sufficiently great to have had some influence on the streams, and on the topography which they fashioned.

The Hackensack valley.—In the post-Cretaceous erosion interval, a valley of undetermined depth had been excavated between the Palisade ridge and First mountain. During the Beacon Hill submergence, this valley was largely filled, so that, on the re-emergence of

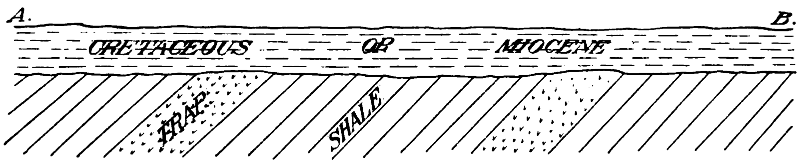


Fig. 24.
Diagram illustrating superimposition of streams. A stream flowing in the direction *A B* has a course in disregard of structure.

the surface in post-Beacon Hill time, re-excavation began. It was during the period of erosion which followed that the final excavation of this valley was begun, and carried, not to its present depth, but to a depth accordant with the stand of the land at that time.

Except for that part of the Passaic system which comes from west of Second mountain, the drainage of this region probably corresponded closely with that of the present time. It is not probable that the

Watchung mountains on the one hand, and the Palisade ridge (or at any rate its north end) on the other, were so completely buried beneath the Beacon Hill formation as not to affect the surface. If these ridges did not exist as such at the time of the post-Beacon Hill uplift, they must soon have assumed a ridge-like character, for erosion could not have lowered the hard trap as rapidly as it brought down the less obdurate sands, gravels and clays, which had just been deposited, or the shale and sandstone beneath. If, therefore, these elevations were not ridges or divides at the beginning of the post-Beacon Hill erosion cycle, they soon became such, for no streams except large ones could long have held their courses across them. If, therefore, the streams (except the Passaic) flowing southward between the Palisade ridge and First mountain did not, at the outset, assume their present or essentially their present positions, they soon acquired them, for they could not have been long in adjusting themselves to the rock structure which they discovered as soon as they had cut through the Beacon Hill formation.

Fig. 25.

Cross-section of the Hackensack valley from Palisade ridge to the Highlands a little south of the State line. The dotted line represents the surface of the valley as it is believed to have existed at the close of the pre-Pensauken cycle of erosion. The full line represents the present profile.

The level to which the great valley between the Palisade ridge and First mountain was brought during this period of erosion is now marked by the low ridges and swells of sandstone or shale which rise 100 to 200 feet above the general level of the broad depression in which they stand. It is not known how far erosion had proceeded in this region in post-Cretaceous and pre-Beacon Hill time, but in its later excavation, the valley was developed by the removal, first, of the Beacon Hill formation, and of any remnants of Cretaceous which had escaped removal until this time; and second, by the wearing down of the Triassic sandstone beneath.

The Palisade ridge to the east of this valley rises at its northern end 200 to 300 feet above the lesser sandstone ridges which mark the bottom of the valley as it was at the close of this period of erosion, while First mountain to the west rises 400 to 500 feet above them. Fig. 25 represents a cross-section of the Hackensack valley as it now is (full line), and as it is believed to have been (dotted line) at the

close of the erosion cycle (or partial cycle) now under consideration, the same cycle as that which developed the Kittatinny valley. From the proportions of the great valley developed at the time under consideration, it is clear that the erosion interval was long.

During the development of this great valley it is probable, though hardly certain, that the Pompton river, after gathering in the waters of the Pequannock, Wanaque and Ramapo, flowed eastward across Second and First mountains at Little Falls and Paterson, as now. It is doubtful if the Rockaway joined this system, and the upper basin of the Passaic was quite certainly drained along another line.

The Upper Passaic valley—It was at the time of the development of the great Hackensack valley that the extensive flat west of the Watchung mountains (later the basin of the extinct Lake Passaic) was developed; or if it had been partially developed before the deposition of the Miocene, and then filled by the later beds, it was now re-developed. The drainage from this region was then very different from that which now obtains in the same region. The capacious Upper Passaic basin was drained by a stream which crossed Second and First mountains, near Summit and Millburn respectively, and flowed thence direct to the sea (Fig. 4, p. 51), instead of following the present roundabout course of the Passaic. The broad flat northwest of Second mountain was developed by this stream and its tributaries. That this was the course of the drainage is inferred from the facts already cited. The divide between the drainage system which discharged across First and Second mountains at Summit and Millburn, and that which crossed the same mountains at Little Falls and Paterson, is not known. It seems quite as likely that the Rockaway joined the lower system as the upper. How the Passaic river came to take its present circuitous course will be stated later.

No region illustrates better the topographic effect of hard and soft rock than the upper basin of the Passaic. While the hard trap ridges of First and Second mountains had only broad notches cut through them at Millburn and Summit respectively, the country above (west of) these ridges, being of soft rock, allowed the development of very wide flats at the same time. Thus the main stream and its tributaries developed, above the ridges, a broad plain essentially as low as the level of the relatively narrow valleys across the ridges themselves.

The extent of the erosion in this region, like that between the Pali-

sade ridge and First mountain, indicates that the erosion interval was long.

The branches of the Raritan.—As in the other cases, so also in the valleys of the branches of the Raritan the erosion of this period is not separable from that which followed the post-Cretaceous uplift. From the standpoint of topography, the erosion of the two periods seems to belong to the same cycle. During this cycle, the stream which occupied the valley of the South Branch of the Raritan was cutting its upper course through relatively hard rock. From Succasunna Plains to Califon, the rocks were less resistant than from Califon to High Bridge, and the valley was made more capacious in the former stretch than in the latter. But when the stream escaped from the Highlands at High Bridge, it found itself on the Triassic conglomerates and shales so soon as it had cut through such beds of the Cretaceous and Beacon Hill formations as may have covered them, and its valley was immediately expanded. For the first few miles of its course below High Bridge, the expansion was not great, for the trap of Cushetunk mountain on the one hand, and the obdurate beds of the Hunterdon plateau on the other, restricted its development; but once beyond these formations of hard rock, the stream developed a valley which expanded to a wide plain.

The same was true of the valley of the North Branch. So long as it and its tributaries flowed over the crystalline schists, their valleys remained narrow, but where they reached the Triassic shale north of Bedminster, they expanded promptly and formed a great plain, which became continuous to the south, with the plain of the South Branch. The extent of these valley plains is conclusive evidence of the considerable duration of the erosion interval.

The plains then developed by these streams and their tributaries are now represented by the low, flat divides between Bedminster on the northeast and Flemington on the southwest, rising to heights of a little more than 200 feet above the sea. The same plain was continued westward beyond the South Branch proper, in the basin of the Neshanic, and still farther west, through the broad depression which separates the Hunterdon plateau on the north from the Sourland Mountain plateau on the south. The configuration of this part of the plain, which rises toward the west, its highest portion being within three or four miles of the Delaware river, seems to indicate that the drainage between the plateaus mentioned was chiefly to the

eastward, by way of the Neshanic, to the Raritan river, not to the westward to the Delaware. The divide between these drainage systems is still in this position. For this there is good reason in the fact that along the course of the Raritan, as it then flowed (see Plate X., p. 102), there was less hard rock than along the course of the Delaware. The former, therefore, deepened its valley more rapidly than the latter, and gathered to itself the drainage of the larger part of this area.

In the vicinity of Somerville, nearer the main streams and farther down their courses, the areas that seem to correspond with those just referred to are less than 200 feet high. South of Millstone, and between that village and New Brunswick, the corresponding surfaces are about 130 feet in elevation, and similar heights are found on corresponding surfaces about Metuchen, and between that village and New Brunswick, and between New Brunswick and Sand Hills, near Monmouth Junction. It is a notable fact that the existing remnants of this old surface are quite as high about New Brunswick as about Somerville, *much farther up the stream.* If the rock about New Brunswick were notably harder, this would explain the difference, but since, with local and minor exceptions, it is not, the explanation is to be sought along other lines.

The explanation of this peculiarity of surface is probably to be found in the fact that the two branches of the Raritan, after joining in the vicinity of the village of South Branch, did not follow their present course much below Somerville. After reaching a point a little below that city, the Raritan turned southward up the present valley of the Millstone to the point where this stream is joined by Stony brook. Thence its course was up the present valley of Stony brook to Port Mercer, where Stony brook makes a remarkable bend. Thence it flowed to the southwest over the low divide (which now nowhere rises above 60 feet) between Stony brook and Shipetaukin creek, down Shipetaukin creek to its junction with the Assanpink, and thence down the Assanpink to the Delaware. With this course for the master stream, it is not strange that the plain developed at this time should have been as high about New Brunswick, which was not close to a large stream, as about Somerville, which was.

With the Raritan flowing in this course, its valley became wide in the vicinity of Somerville and Millstone, where the bed-rock was relatively soft, and much narrower from Griggstown to Kingston,

where the rock was relatively hard. Below the latter point, after passing the hard trap of Rocky hill, the valley again became wide.* This being the course of the Raritan, it is easy to understand the presence of the great valley plain extending from Trenton northeast to Penn's Neck and beyond, a valley the capacity of which is altogether out of keeping with the size of the streams which now occupy it.

Since the Raritan river assumed this course after the uplift following the deposition of the Beacon Hill formation, it must be that the Rocky Hill ridge did not then exist as a topographic feature. It was probably completely buried by the Cretaceous and Miocene, and the Raritan flowed across it unheeding, and turned to the southwest to join the Delaware.

When, after cutting through the Cretaceous and later formations, the Raritan found its channel on the Triassic rock beneath, it doubtless deepened its bed less rapidly. It seems probable that the surface of shale on either side of the trap was as high, or nearly as high, as the surface of the trap itself; for the Triassic surface in this region had been base-leveled before the deposition of the Raritan. Subsequently it had been buried by the Cretaceous, which in the succeeding erosion interval had not been entirely removed. The Raritan, therefore, probably found itself flowing on the trap, and on the shale north and south of the trap, at about the same time.

These relationships apparently offered a good opportunity for adjustment. Had there been a vigorous stream working its head to the westward from the vicinity of Raritan bay, *north of the Rocky Hill range,* it might have tapped the Raritan north of this trap ridge and carried it off to the east. But the initial slopes after the uplift of the Beacon Hill formation appear to have been such that for some distance east of the Raritan the streams were flowing to it, instead of eastward to the sea.

Again it might be thought that a tributary to the Delaware heading back to the east *north of Rocky hill,* might have reached the Raritan and carried it off captive to the west. But the difficulties in this direction were greater than in the other, since a tributary from the Delaware, to have captured the Raritan, would have been obliged

* It should be borne in mind that the depths and widths of valleys here referred to are not those of the present time. The valley plains here considered are those developed at the time indicated—plains which, about Somerville, Millstone and New Brunswick, now stand at elevations of 130 feet to 150 feet

to work its head back on the hard Lockatong shales, even if it could have avoided the trap. Meantime, the Raritan, being a large stream, was able to lower its valley across the hard trap of Rocky hill rapidly enough so that no other valley heading back either from the east or west, could offer it a more favorable route to the sea. Hence

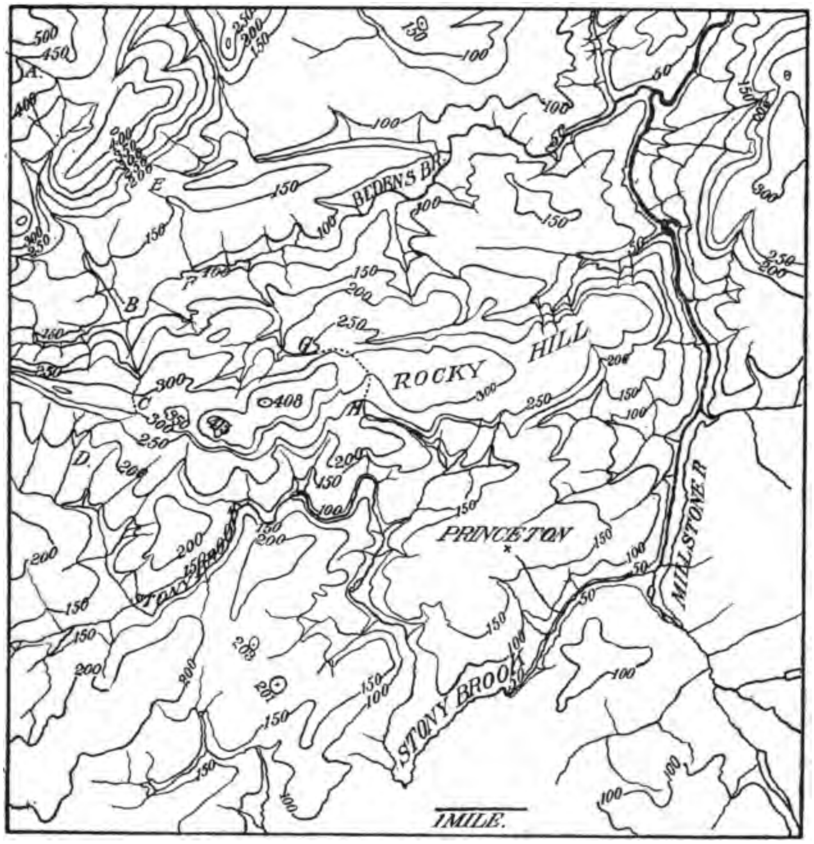


Fig. 26.

Illustrating probable adjustment of streams across the Rocky Hill range west of the Millstone.

it held its course across the Rocky Hill range to the end of the cycle now under consideration.

It is probable that some small streams which at the outset crossed the site of the Rocky Hill range, were diverted to some other course as soon as the removal of the softer shale allowed the trap to stand out as a ridge. This was probably true, for example, of streams

which descended to the southeast from the Sourland Mountain plateau. Thus the stream (Fig. 26) heading near *A* (northwest corner of the map) may at the outset have followed the courses *A*, *B*, *C*, *D*, to Stony brook; and the stream heading at *E* (southeast of the last) may have followed the course *E*, *F*, *G*, *H*. But Beden's brook, then tributary to the Raritan (now to the Millstone), heading back from the Raritan, which flowed through Rocky hill, offered these streams a lower line of flow in that direction, and of this they were quick to take advantage. Thus Rocky hill, west of the main stream, became a divide.

Throughout the post-Beacon Hill period of erosion, then, the Raritan river was tributary to the Delaware. This course of the Raritan river determined the direction of many tributary streams. The streams occupying the position of Bound brook, Green brook and Ambrose brook likewise flowed to the southwest as now, joining the Raritan not far from the village of Bound Brook. From the Sourland Mountain country, which is believed to have been covered by the Beacon Hill formation, the streams flowed partly to the southwest to the Delaware and partly to the southeast to the Raritan. From the east and southeast, streams likewise flowed to the west and northwest toward the master stream from the vicinity of Jamesburg Dayton, Hightstown and Newtown. It seems probable also that from even farther east the drainage was toward the Raritan and Delaware, instead of directly to the ocean. It is well possible that South river itself joined the Raritan, and through it the Delaware.

The southerly course of the Raritan below the junction of its two branches was doubtless determined by the initial slope given the surface at the time of its uplift, after the deposition of the Miocene. But below Rocky hill, instead of continuing in its southerly course it turned to the southwest. What was the obstacle which prevented it from holding its course to the south across the Coastal plain?

There is some reason to believe that the low belt along the Fall line from the head of Raritan bay to Trenton was all along a zone of weakness. If during the uplift after the deposition of the Beacon Hill formation there was a slight sag along this belt, or a lesser elevation as compared with the territory on either side, the result would have been to give the surface over which the Raritan flowed, from Somerville to Penn's Neck, a slope to the southward, a slope with which the course of the stream to the latter point agreed. If there

was a relative depression along the belt in which the Fall line lies, the Raritan could not have continued its course to the south beyond the axis of the sag belt (Penn's Neck), for beyond that axis the slope was to the north or northwest. On reaching this axis, therefore, the stream turned so as to flow along it. Since the southwest direction, rather than the northeast, was chosen, it must be inferred that this was the direction of greater slope.

A slight excess of uplift along some such line as *X Y* (Plate X.) would have had the same effect as a depression along the Fall line, in deflecting the stream to the southwest. It is to be noticed that the Delaware river, coming down from the north, was likewise deflected to the southwest, and that just below the point where the Raritan joined it. The initial course of the Delaware may not have corresponded exactly with the present, but it does not appear to have departed widely from it. Such a depression, or such an elevation, or both, would have served to turn the Delaware river into its present southwest course below Trenton, at the same time that the Raritan was turned from the south to the southwest along the old course now abandoned. It does not appear that either the sag or the uplift was great, and perhaps the best single line of evidence for the existence of either is found in the course of these two streams. The course of the Delaware has persisted throughout all later time, but the changes in the course of the Raritan are among the most considerable changes which the drainage of New Jersey has suffered since the time now under consideration. The only other changes comparable in importance are those affecting the Passaic system.

Duration of the pre-Pensauken erosion cycle.—The duration of the post-Beacon Hill erosion period, as shown by the great development of valley plains north of the Fall line, was great. To this conclusion the broad valleys between the Palisade ridge and First mountain, between Second mountain and the Highlands, and along the North and South Branches of the Raritan, as well as along the courses of the stream made by the union of these branches, bear unmistakable testimony. On the other hand, it is to be noticed that these valley plains became greatly expanded only where the underlying rock was relatively soft. Where the streams, after cutting through the Beacon Hill formation, found themselves on the non-resistant shales, wide valleys were developed; but where they found themselves crossing the outcrops of trap, the valleys were not greatly expanded. While, therefore, the

erosion which followed the uplift of the Beacon Hill formation was great enough to bring broad belts of land along the main streams where the rock was soft, nearly to base-level, it was not great enough to bring the hard rock to the same level, except along the immediate channel of the larger streams. Indeed, the hard layers of trap rock, such as Rocky hill and the Watchung mountains, isolated by the removal of the soft shale on either hand, were little affected, except where crossed by streams. Through Rocky hill, at Kingston, the Raritan cut no more than a narrow, gorge-like valley. While the Passaic, at Summit and Millburn, and the Pompton, at Little Falls and Paterson, cut wide valleys through First and Second mountains, they were still narrow as compared with the great plains developed by the same streams where the rock was less resistant.

Stand of the land.—During most of this erosion cycle, the surface of the Piedmont plain seems to have stood at a tolerably constant level. If there were oscillating movements they are not now recorded. The altitude at which it stood was somewhat less than that of the present time; that is, the crests of the Watchung and Sourland mountains, cut down but little since the beginning of this cycle, were a little lower than now, and all of the formations now existing were lower than at present by an amount ranging from something more than 100 feet nearly to zero.

Nomenclature.—This period of erosion lasted long enough to develop extensive base-levels in the vicinity of the main streams where the rocks were soft. From the great development of such surfaces in the area about Somerville, Davis proposed to call it the Somerville* peneplain. Elsewhere he has called it the Tertiary peneplain, a name which was meant especially to distinguish it from the Cretaceous peneplain and to indicate that it was of later development.

Neither of these names is satisfactory, although each is based on a sound principle. The name first mentioned, the Somerville plain, is meant to suggest a locality where the plain may be seen to advantage; but unfortunately for the name, Somerville does not stand on the plain developed at this time, but in a broad valley below it, a valley developed at a later time. It is true that the plain is well shown within a few miles of Somerville, but that does not make the name an ideal one. There is, unfortunately, no city or village of any con-

* "Geographic Development of Northern New Jersey," Proc. Bos. Soc. Nat. Hist., p. 391.

siderable size situated upon the plain which seems to afford a good name for it. In the Piedmont plain (Triassic), the villages of Franklin Park, Middlebush, Clyde, Voorhees, Adams Station, Deans Station, Ewingville, Lawrenceville, Pluckamin, Bedminster, White House, Lamington, Reaville and Clover Hill stand upon it; but no one of these places is sufficiently well known to make its name a good one for the plain.

The name Tertiary is based on another principle, viz., that of giving to the plain the name of the period when it was developed. The name Tertiary was used primarily to distinguish this plain from the Cretaceous peneplain of earlier date, and to give some idea of its date of origin. But on this basis the name is no longer satisfactory, however appropriate it may have been when first suggested. The Tertiary periods represent an exceedingly long interval of time, and it is now known much more definitely than this name indicates, when the plain in question attained its best development. A later subsidence brought much of the peneplain below sea level, and a new formation was deposited upon it. This formation was the Pensauken, and since the plain was at its best just before the submergence which allowed the Pensauken beds to be deposited, it is proposed to call it the *pre-Pensauken* peneplain. This locates its time of origin in terms of a formation which has now been clearly defined. In time it seems to have been near the close of the Tertiary.

D. THE PRE-PENSAUKEN EROSION CYCLE IN THE COASTAL PLAIN.*

While the great valleys between the Palisade ridge and First mountain, and between Second mountain and the Highlands, were being excavated, and while the broad plains along the North and South Branches of the Raritan were being developed, the lesser streams of the Coastal plain were likewise active.

At the beginning of the pre-Pensauken cycle of erosion, the Coastal plain in New Jersey is to be thought of as a rather featureless plain, the highest belt of which lay along the line *X Y* (Plate X., p. 102). From this axis there was a very gentle slope both to the northwest and to the southeast. Along the axis itself there was perhaps a slope to the northeast and southwest, for the uplift appears to have been

* In this sub-section and in what follows, I have drawn largely upon data collected by Mr. Knapp, and have made use of some of his conclusions.—R. D. S.

slightly greater along its central portion than at either end. Unequal uplift along this line, resulting in the deformation here suggested, has taken place at some time, though possibly it was not until later.

About the margins of the Coastal plain, as it emerged from the sea with its cover of Beacon Hill sand and gravel, streams began to develop (see Plate X., p. 102). On the east and south they flowed directly to the sea; on the west they flowed to the Delaware, and on the north and northwest, north of the axis X Y, they flowed to the northwest, joining the Raritan.

So soon as formed, each of the numerous small streams began at once to deepen and widen and lengthen its valley. While these streams were much smaller than many of those (like the Raritan) which flowed over the Piedmont plain, they were nevertheless not so far behind them in the results which they effected as their difference in size might lead one to infer, for while the larger streams farther north were working away at shale and trap, the smaller streams to the south were sinking their valleys in unindurated sands, clays and marls. While the larger streams farther north were developing the great plains which have been referred to, the smaller streams likewise brought considerable areas within their drainage basins to the condition of fluvial plains. The river plain along one drainage system widened until it became confluent with that of its neighbor systems on either hand, and the result was that by the end of the erosion cycle the marginal portion of this part of the State (see Plate X), was brought down essentially to base-level. To the north, this plain was continuous with the pre-Pensauken peneplain in the Triassic area, or Piedmont plain. The pre-Pensauken peneplain was, therefore, an area of wide extent, covering a considerable part not only of the Triassic area, as now exposed, but of the Coastal plain as well.

While the streams were working at the borders of the Coastal plain on all sides, their work was very unequal. Along the western border flowed the Delaware, joined by a series of tributaries comparable to those which flowed to the south and to the east directly to the ocean. Since valleys normally develop headward, it will be seen from the map (Plate X) that the streams of the Coastal plain were all headed for its central portion. It is not apparent that the streams flowing to the northwest had any pronounced advantage over those flowing to the southeast, or that the latter had any advantage over the former, except such as the differences in the character of the

rock offered; but it is probable that the streams flowing from the axis *X Y* (Plate X.) northwest to the Raritan and Delaware had rather higher gradients than those flowing to the southeast, and that erosion along the northwest side of the plain was therefore somewhat more rapid than elsewhere.

In addition to the advantage of slightly higher gradients, it is probable that the character of the formations also favored erosion in the region northwest of *X Y*. This was perhaps not true until the streams had cut through the Beacon Hill formation into the Cretaceous beneath, but the greater altitude of the surface along the axis, and the greater slope to the Raritan and the Delaware, allowed the streams to cut through the Beacon Hill formation in this region sooner than elsewhere. It is probable, also, that the Beacon Hill formation was thinner here than to the southeast, and it is certain that the base of the Cretaceous was higher. In deepening their valleys, therefore, the streams reached the Cretaceous earlier along the northwest side of the plain, than in the area southeast of the axis *A B*.

Reaching the Cretaceous formations beneath the Beacon Hill beds, the streams encountered a heterogeneous structure. The principal points in the structure of the Cretaceous beds which influenced the erosion of the cycle which followed the emergence of the Beacon Hill formation are (1) the slight dip of the beds to the south of southeast, and (2) the unequal resistance of the various layers of the formations themselves.

The Cretaceous formations are divisible into three principal series, These are (1) the Raritan formation, lying at the base; (2) the Clay Marl or Matawan series, lying in the middle, and (3) the Marl series, including the Lower Marl, the Red Sand, the Middle Marl the Lime Sand and the Upper Marl of Cook, or the Navesink, Red Bank, Rancocas and Manasquan marls of Clark.* The first and second divisions, as well as the third, are capable of subdivision, each being made up of layers of different constitution and of different powers of resistance.

The Raritan formation is made up of a series of beds which are principally clay, but which nevertheless contain seams, and in places considerable pockets and layers of sand and gravel. On the whole, the constitution of this formation is markedly heterogeneous, and

*Annual Report for 1893, p. 334. More recently (Maryland Geological Survey, Vol. I., Part III.) Clark proposes to set off the upper part of (2) and the lower part of (3), under the name of the Monmouth formation.

heterogeneity of composition favors erosion. As a whole, therefore, the Raritan formation is easily eroded.

Next above the Raritan formation, and like it dipping gently to the southeast, lies the Clay Marl (Matawan) series, which constitutes the second major division of the Cretaceous. It consists of alternating beds of sand, clay and marl, and is, on the whole, an easily-eroded formation. Its various layers, however, possess very unequal powers of resistance. Some are highly ferruginous, and in the changes which the beds have undergone since their deposition, certain portions have become more or less completely cemented. The cementation has frequently affected the layers of sand, converting them into sandstone, cemented by iron oxide. Such a layer of sandstone occurs at many points near the middle of the Clay Marl series, and the exceptional resistance which this cemented layer offers to erosion has caused it to give rise to notable prominences, so that, at the end of the cycle, many low hills marked its outcrop across the State. The sand beds where not cemented, and a notable stratum of micaceous clay, are the least resistant members of the Clay Marl series, and the clay beds and the cemented sand have withstood erosion most efficiently. Iron oxide, apparently derived from this formation, has sometimes been carried down by underground waters into the Raritan sands beneath, cementing them into more or less firm sandstone.

In general, it may be said that the Raritan and Matawan formations are more easily eroded than the uppermost division of the Cretaceous, and that the streams were most effective on these formations, both in this cycle and the next. This was partly because of the greater elevation of these formations.

The third group of formations of the Cretaceous is the Marl series lying above the Clay Marls, or Matawan series. This series is, on the whole, more resistant than the beds below, and has been less deeply eroded. One result of its greater resistance to erosion is that its northern edge is marked by a steep, often scarp-like face (see *S*, Figs. 1–3, Plate XI.) The lowermost division of the Marl series—the Lower Marl—is more easily eroded than the Red Sand immediately above it. The base of the Middle Marl, which overlies the Red Sand, is very commonly cemented, and the Red Sand—itself a more or less resistant formation—together with the cemented bed of the Middle Marl at its top, has given rise to some of the more striking topographic features of the Coastal plain. It is the cemented layer at the base of the

Middle Marl, lying on the top of the Red Sand, which has given origin to the narrow, ridge-like divides and elongate hills in the vicinity of Beacon hill and Telegraph hill, and to some of the hills between Red Bank and Atlantic Highlands. Above the cemented bed at its base, the Middle Marl is more easily eroded.

The Delaware and the Raritan rivers, below Trenton and Rocky Hill, respectively, both had their courses along the strike of the Cretaceous beds. It follows that the tributaries from the southeast had their courses across the outcrop of the beds essentially at right angles to the strike, while the tributaries to these tributaries, that is, the streams of the third order, had courses essentially parallel to the master streams. Since the streams tend to bring their courses into parallelism with the strike of the beds over which they flow, the streams of the third order soon adjusted their courses to the structure of the Cretaceous, when not in adjustment at the outset.

It should be noted that the structure of the Beacon Hill formation itself was much like that of the Cretaceous, so that the adjustment here referred to began, and was perhaps perfected before the streams had cut through the former to the latter. Perfect adjustment in the upper formation, however, might not have meant perfect adjustment in the lower.

The more easily eroded beds of the Raritan and Matawan series offered exceptional advantages for the development of the streams of the third order, the courses of which were parallel to the strike. This system of stream adjustment facilitated the rapid degradation of the region, and helped the streams to develop broad plains, and together, a broad peneplain, almost a base-level, bordering the Delaware and the lower course of the Raritan. Above the peneplain the more resistant layers of the Raritan and Matawan formations rose, forming low but sometimes abrupt hills and ridges. Near the middle of the Matawan there is a bed of ferruginous sand, often cemented by iron oxide into a more or less firm sandstone. Along the line of the outcrop of this bed, the surface was not brought to base-level in this cycle, and at the end of the cycle the outcrop of the bed was marked by a series of low hills which still persist. Here belong, among others, the 121-foot hill two miles southeast of Bordentown, the 110-foot area in the vicinity of Mansfield, the 108 and 106-foot hills southeast and south of Mansfield Square, the 115-foot hill one and one-half miles southeast of Deans Station, the 100–109-foot hill a mile west of Columbus, and the 103-foot hill northwest of Jacksonville (Burlington county).

The uppermost member of the Clay Marl series was likewise somewhat more resistant than that just below, and as a result it was in many places not degraded to the same extent as the next underlying bed, and gave origin to low hills lying just northwest of the scarp-like outcrop of the Marl series.*

The upper portion of the Clay Marl series is, on the whole, more easily eroded than the lower portion, and therefore afforded good opportunity for the development of wide valleys along the line of its outcrop. The easily-eroded micaceous clay near the top of the series, and therefore but little below the base of the Marl series, tended, on the one hand, to push the base-plain of erosion to the southeast, well to the base of the marls, and on the other to make the beds of the Marl series, some of which were more or less cemented by iron oxide, stand out in a scarp-like face as degradation progressed (see Fig. 27).

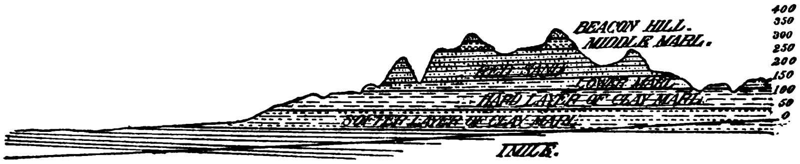


Fig. 27.

Profile, partially diagrammatic, showing the effect of the inequalities in the Cretaceous beds on topography. The section is at right angles to the strike of the beds.

The general result of the unequal resistance of these main divisions of the Cretaceous was to develop a belt of low land along the outcrops of the Raritan and Matawan series (interrupted more or less by the hills along the outcrop of the cemented layers of the latter), and to leave the outcrop of the Marl series as a belt of high land, with a scarp-like face to the northwest and a gentler slope to the southeast.

The pre-Pensauken erosion cycle went on uninterruptedly, so far as can now be seen, until that part of the Coastal plain outside the irregular line *a, b, c, d, e, f,* Plate X., p. 102, had been brought nearly to base-level. At its close there was a peneplain around the eastern, southern and western portions of the Coastal plain. From the vicinity of Trenton, the plain stretched northeast to the head of Raritan bay. Sections I., II., III. and IV., Plate XI. (p. 122), taken across this peneplain along the lines *1–1, 2–2, 3–3, 4–4* of Plate X., serve to show the profile of the region at the time. From them the extent of the

* It is this bed which Clark now makes the base of the Monmouth formation.

PLATE XI.

EXPLANATION OF PLATE XI.

The Sections I., II., III. and IV. are along the lines *1–1*, *2–2*, *3–3*, and *4–4*, respectively, of Plate X. In each section *S* represents the scarp face of the Marl series. In each section the dotted lines *A B* represent the pre-Pensauken peneplain, and in each the dotted line *Cr* represents the deformed Cretaceous base-level.

peneplain is seen. Erosion of a later date has modified the surface as it was at the close of this cycle, but in these sections the line *A B* is the restored surface of the peneplain as it then existed. The prominences which, in the profile, stand out above the peneplain level, *A B*, were prominences at the close of the cycle. They stood somewhat higher above the peneplain at that time than now.

From Sections I. and II. it will be seen that the peneplain *A B* was a broad flat, bordered on the northwest and southeast by high, steep-sided hills. In Section III., the peneplain *A B* is quite as wide as in Sections I. and II., but the border highlands are not so high. In Section IV., the peneplain is much narrower, and the uplands bordering it to the northwest and southeast are low. By reference to Plate X., it will be seen that the breadth of the peneplain *A B*, in Section III., is definitely related to Rancocas creek—is, in fact, the work of this creek during this cycle.

The pre-Pensauken peneplain in the basin of Rancocas creek.—How Rancocas creek chanced to outstrip its neighbors in lowering its drainage basin, carrying the pre-Pensauken peneplain along its course far to the southeast, as indicated on Plate X., is an interesting question. The explanation is probably to be found in the local variation in the character of the Cretaceous and Beacon Hill terranes. These variations are of such a character, and so located, as to have afforded the Rancocas favorable opportunity for effective work.

Of the variations in the Beacon Hill formation which may have favored erosion in the basin of the Rancocas, little can be said, since the formation itself has been almost entirely carried away. The character of the Cretaceous beds, however, is known, and seems to afford an adequate explanation of the great erosion of this creek and its tributaries.

The upper Cretaceous beds are not uniform from northeast to southwest. The Raritan and the Matawan series remain much the same in the basin of the Rancocas creek as elsewhere, but traced from the northeast the Lower Marl becomes more granular and less compact, and at the same time thinner. Both its change of texture and its diminishing thickness work to the advantage of stream erosion. The Red Sand which belongs next above the Lower Marl stratigraphically, and which to the northeast is the most potent factor in forming the obtrusive range of high hills extending southwest from Navesink Highlands, becomes thinner to the southwest, and Mr. Knapp thinks is either

entirely absent in the basin of Rancocas creek or changes its character notably. In the vicinity of Rancocas creek, the Middle Marl also is more easily eroded than to the northeast, for in the latter direction this member of the Cretaceous series is often cemented by iron oxide, and has been a potent factor in developing and preserving the range of high hills and sharp-crested ridges of which Beacon hill and Telegraph hill are examples. This "shelly marl," as it has been called on account of its cementation, is, like the Red Sand, a hill-making bed, but in a different sense. The Red Sand bed is itself so thick in the northeastern part of its outcrop that it constitutes the hills, while the Middle Marl only furnishes a capping which helps to preserve their crests. This phase of the Middle Marl is entirely absent in the basin of Rancocas creek. The higher members of the Marl series, viz., the Lime Sand and the Upper Marl, are present in the basin of Rancocas creek, and both are eroded with facility.

The great development of the base-level plain in the basin of the Rancocas is therefore to be connected with the variation in the character of the Cretaceous beds in this region, variations which directly facilitate erosion. It is mentioned especially in this connection as affording a good illustration of the manner in which one stream outstrips another in the struggle for existence, when the cause is not, at first sight, obvious.

Special point is given to the suggestion that it was the local variation in the character of the Cretaceous beds which made the great flat of the Rancocas drainage basin possible, by the fact that Crosswicks creek, which was fully as large as the North Branch of the Rancocas, and which pushed its headwaters during this erosion cycle nearly as far to the southeast as did the Rancocas, was able to cut for itself only a comparatively narrow valley across the high marl belt in the vicinity of Cream Ridge, a valley two miles wide at most, whereas Rancocas creek at the same time totally obliterated the high land along the outcrop of the marls, for a distance of more than fifteen miles, excepting only two little cone-like hills, Mount Holly and Mount Laurel.

The Beacon Hill formation, which overlay the Cretaceous, may have likewise favored erosion in the basin of Rancocas creek, as against the region farther northeast. The only reason for suspecting that this may have been the fact is that the Beacon Hill formation, just south of the basin of the Rancocas, is somewhat different in com-

position from that which lies to the northeast, indicating that the material was derived from a different source.

The variations in the Beacon Hill formation suggest that, at the time of its deposition, the sediments came to the sea from several different sources by several different routes. Two of these were the Delaware and Schuylkill rivers. The material brought down by the Delaware was spread out near its mouth in the form of a huge fan, while that brought down by the Schuylkill, reaching the sea water near the present site of Philadelphia, was likewise spread out in another huge fan southeast of Camden. The Rancocas creek occupies the position which, it is believed, marked the contact of the Delaware fan with that of the Schuylkill. It is well possible, therefore, that the depositional surface along the line of this creek was slightly lower than that on either hand at the outset. If this be true, it would have favored the ready development and the rapid progress of a stream in this locality, in which case the Rancocas had an advantage over its neighbor streams from the beginning.

The structure of the Cretaceous—the more resistant Red Sand and Middle Marl overlying the less resistant Raritan and Matawan formations—gave the pre-Pensauken peneplain on the northwest border of the Coastal plain an abrupt southeastern limit. Along the course of the Delaware there was a similar scarp along the east base of the peneplain. This was especially true south of Cooper's creek, where the uplands lying east of the peneplain often present an abrupt front to the west. Here, however, the scarp was formed by the Beacon Hill (and Miocene), especially where the gravel member of the Beacon Hill was sufficiently heavy to form a protecting cap for the underlying sands. The Beacon Hill gravel here served the same function in the development of topography as the Red Sand and the Middle Marl farther northeast. That the Marl series does not here play a more conspicuous part is due in part to the fact that its surface was not sufficiently high above sea level.

All along the west side of the Coastal plain the tributaries to the Delaware developed plains like that of the Rancocas, but less extensive. The streams flowing south and east to the ocean, the Maurice river, the Great Egg Harbor river, the Mullica river, Toms river, the Manasquan river and Swimming river, were likewise developing valley plains along their courses—plains which, individually, were comparable with the plains of the tributaries to the Delaware. The

Mullica and Great Egg Harbor rivers, especially, succeeded in developing wide plains, which extended well back into the heart of the Coastal plain. The plain of the Mullica, developing from the east, extended so far west as to virtually meet the head of the plain of the Rancocas, which was developing from the west. At the close of the cycle, the central portion only of the Coastal plain remained well above the peneplain level. Even this was much dissected by valleys.

The stand of the land in the Coastal plain during the pre-Pensauken erosion cycle.—It is now possible from the topography at some points on the Coastal plain to determine the approximate stand of the land at the time this erosion was in progress. This is determined by the present altitude of remnants of the old peneplain which must have been developed not far above sea level. In this way we learn that the Coastal plain did not at that time stand as high as now. In the vicinity of Beacon hill, the present summit of the elevations stood about 250 feet above sea level; that is, about 150 feet lower than now. The summit of Mount Holly stood about 150 feet above the sea, or about 30 feet lower than now. At Glassboro the surface of the land was only about 90 feet above the sea, an elevation somewhat less than the present. From these relative elevations it is clear that the surface between these points has since undergone differential uplift.

Deformation.—The Mount Pleasant hills are nearly as high as the Rocky Hill range, which belongs to the Schooley cycle, but the formations out of which the Mount Pleasant hills were carved were not yet in existence when the Schooley peneplain was developed. It is clear, then, that in post-Cretaceous time the Cretaceous formation and all that lay above it along the line of this range of hills, was elevated more than the south edge of the Schooley peneplain. Carried southeast from the Rocky Hill range to the region of Clarksburg with the same slope which it has farther north, the Schooley peneplain would have declined nearly to sea level.

Extent of erosion in the Coastal plain in the pre-Pensauken cycle of erosion.—The Navesink-Clarksburg range of hills gives some clue as to the level from which the pre-Pensauken peneplain was cut down. These elevations rise, in the Mount Pleasant hills, 250 feet, and in the vicinity of Clarksburg 200 feet, above the peneplain to the north, so that the lowering of the surface in this part of the Coastal plain in the pre-Pensauken cycle was as great as in the Piedmont plain.

Southeast of the Navesink-Clarksburg range of hills, a very large part of the surface of the State was low at the end of the pre-Pensauken erosion cycle. Much of it had never been high, and on it but little erosion had taken place. That part of it which had been elevated to sufficient altitude had suffered erosion to such an extent as to be largely reduced to low levels, though its surface was still marked by some notable elevations, and by some rather broad interstream areas which had not been brought low.

A subordinate uplift.—There are some phenomena of the Coastal plain which indicate that just before the subsidence which allowed of the deposition of the next succeeding formation, the peneplain already developed was lifted slightly, rejuvenating the streams, and causing them to cut narrow gorges in the surface of the peneplain. Thus the stream (the Raritan) occupying the valley of the Millstone had cut a valley 60 feet below the level of the peneplain at Kingston just before the deposition of the next formation, and the Rancocas creek sank its channel 50 feet into the peneplain, at the same time. Either by erosion or tilting, the area north of the Raritan and east of New Brunswick was brought below the general peneplain level.

The pre-Pensauken peneplain in the Coastal plain, continuous with that in the Piedmont plain.—The pre-Pensauken peneplain about the border of the Coastal plain was continuous to the north with the plain developed at the same time in the Triassic plain (see pp. 99–115). The smaller difference in the character of the rock in the Coastal plain, and its lesser elevation, caused the relief to be less than in the region farther north.

THE CLOSE OF THE PRE-PENSAUKEN EROSION CYCLE.

At the close of the pre-Pensauken cycle of erosion the surface of the region which had been covered by the Beacon Hill formation presented an appearance very different from that which characterized it at the beginning of the cycle. Instead of the featureless plain of the beginning, there were, at the close, broad, flat plains of subaërial degradation along the streams, above which stood hills and ridges in bold relief. In the Piedmont plain, erosion had taken away the soft covering, and the soft surroundings of Sourland and the Watchung mountains, leaving them isolated much as now, their summits being 400 or 500 feet above the sea. Rocky hill, likewise,

had had its covering and its surroundings removed, so that it stood out as a range 300 feet or more above the sea, and trenched, along the course of the Raritan, to a depth of nearly 300 feet. Along the line (*X Y*, Plate X., p. 102) which, at the beginning of the cycle, was the axis of a plain sloping gently to the northwest on the one hand, and to the southeast on the other, there was, at the close of the cycle, a series of high, steep-sided hills, standing out above a flat lowland 200 feet or so below their summit. Stated in other terms, the topographic features which are now most striking in all the region once covered by the Beacon Hill formation were developed by the close of the erosion cycle we have been considering. Since that time they have undergone relatively little change.

The details of the work accomplished by the streams about the southern and eastern borders of the Coastal plain of the State is less well known. This is partly because the region has been less carefully worked, and partly because subsequent submergence and deposition have obliterated in part the work done in this region at this time.

The interval of time necessary to accomplish the erosion results sketched above was a long one. It was sufficiently long for the development of a peneplain ten to twenty miles wide and 100 miles long, bordering the Delaware river and extending northeast to Raritan bay. From the northwestern edge of this peneplain, material to the depth of something like 300 feet had been removed, and from the southeastern edge one-half to one-third as much. Along the northwest side of the peneplain between Trenton and Raritan bay, the material borne away was mainly Beacon Hill and Triassic shale and sandstone, while along the southeastern side it was mainly Beacon Hill and Cretaceous.

SECTION VII.

THE PENSAUKEN SUBMERGENCE.

After the development of the pre-Pensauken peneplain to the extent indicated, the erosion cycle which had developed it was brought to an end by a subsidence which affected much of the State. The extent of the sinking was such that not only the pre-Pensauken peneplain but some of the adjacent lands of slightly higher elevation were brought beneath the waters of the ocean. It was during this depression that the Pensauken formation was deposited, and hence the submergence may be known as the Pensauken submergence.

Considerable areas of the State were not at this time brought beneath the sea, and upon such areas erosion continued much as in the pre-Pensauken cycle. This was true for all areas which remained in such an attitude that the gradients of their streams were not diminished. In the southern portion of the State, and perhaps in the lower lands elsewhere, the gradients of the streams were diminished, and here the streams began a new phase of activity, depositing where they had previously eroded.

If the emergence of the Beacon Hill formation from the sea be called the first event in the topographic development of southern New Jersey, and the erosion which followed the second, the submergence here referred to constitutes the third. The extent of the submergence and its effect upon the distribution of land and water may be inferred from the accompanying map (Plate XII., p. 130), which shows the distribution of land and water at the time of submergence. It will be seen that the land subsided to such an extent as to drown the Delaware river at its lower end, allowing the sea to pass up its valley and over the peneplain which had been developed along it as far as Wilburtha and Washington's Crossing, and that from Trenton, northeastward to Raritan bay, it covered the pre-Pensauken peneplain as developed both on the Cretaceous and on the Triassic beds, forming a broad sound which connected Raritan bay with Delaware bay. The eastern and southern borders of the State were likewise submerged, though knowledge of the facts in this part of the State is at present less definite.

It will be seen that at this time the Delaware river had its mouth in the vicinity of Wilburtha; that Stony brook, instead of joining the Raritan as it had done before, flowed directly into the sea; that the Raritan river no longer joined the Delaware, but that its North and South Branches reached the ocean, or the sound, separately, north and west of Somerville. It will be seen further that at the margin of the sound the sea washed the base of First mountain, Sourland mountain and Rocky hill, and passed as a narrow strait through the gorge which the Raritan had previously cut through Rocky hill. The east side of this hill was, therefore, an island. Southeast of the sound a considerable area of the Coastal plain appears to have remained above the sea, constituting a large island. Northwest of the main island, Arney's mount, Mount Holly, Mount Laurel, Big Mannington hill and a few other isolated points, which had remained as monadnocks on the pre-Pensauken peneplain, were not submerged, but they constituted small, low islands. In Monmouth county there were likewise several islands northwest of the large one. Thus a considerable area centering about Beacon hill and some smaller areas lying farther south remained above the sea. The depressions between these minor islands represent the sites of valleys of the pre-Pensauken cycle of erosion.

All the streams of the Coastal plain were greatly shortened by having their lower portions drowned. The same is true to a lesser extent of the streams coming down towards the old course of the Delaware from the Pennsylvania side.

It is not to be understood that the subsidence took place suddenly. The land probably sank slowly, and the conditions indicated on the map are those which existed when the subsidence reached a maximum. At an earlier stage, the Delaware joined the sea farther south, and at the same time all of the other rivers, shortened at their lower ends by the sinking, had their debouchures in a different position.

It was in the shallow sound extending from Raritan bay to Delaware bay that the Pensauken formation was chiefly accumulated. The material deposited was no doubt derived partly by wave action from the adjacent shores, and partly by streams flowing into the sound. On the northwest side, stream action was more important than on the southeast, since the streams were more numerous and larger. On the other hand, shore erosion may have been quite as effective on the southeast side, since the formations on this side were,

on the whole, an easier prey to the waves. It should he stated, however, that distinct erosion features developed by the waves are not to be found in great perfection. Much of the way between Trenton Junction and Lawrenceville, where the underlying formation is Brunswick shale, there is an indistinct terrace at the level of 120 to 130 feet, which is perhaps due in part to wave action. The material acquired by the waves in the cutting of this bench, so far as it is wave-cut, should be found in the deposits made a little farther out in the sound. In harmony with this suggestion the Pensauken formation deposited in the sound contains its highest percentage of Triassic material in the vicinity of this shore line, but even here the great body of the material deposited seems to have been brought in by the streams which flowed from the Highlands to the north.

The amount and nature of the material brought down by the streams at this time suggest that their activity was not checked during this period, and that therefore their gradients were not diminished. Indeed, judging from the constitution of the deposits in the sound, their activity would seem to have been exceptionally great. This argues either that their gradients were increased, or that they were greatly swollen. The former condition of things would exist if the northwestern part of the State did not participate in the sinking which brought much of the southern part of the State below the sea level; the latter, if there was melting ice in the drainage basins of the southward-flowing streams. There is some reason for believing that the latter suggestion represents the fact, and that the Pensauken formation, though deposited beneath the sea, corresponds in age with the oldest formation of glacial drift.

The northern part of the State is made up of rocks of various sorts. So also is the eastern part of Pennsylvania, which drained into this sound. The headwaters of the larger streams from northern New Jersey flowed down from regions of crystalline schist, shale, limestone, sandstone, conglomerate, etc., of Palæozoic or greater age, while their lower courses crossed the Triassic beds. Some of the shorter streams flowing into the sound had their entire courses on the Trias. The Schuylkill river had its headwaters in the Palæozoic rocks of the Appalachian mountains, while its middle course crossed the Triassic beds, and its lower course the schists and gneisses about Philadelphia. Lesser tributaries gathered materials from less-wide sources. These various streams coming down from the northwest

deposited their load chiefly in the northern or northwestern part of the sound.

The smaller streams entering the sound from the southeast carried materials of a different sort. The formations from which they acquired their load were sands, clays and marls, with a lesser amount of gravel. The shore of the sound on this side was probably somewhat irregular, for it was the streams from the southeast which had been most active and most efficient in the development of the pre-Pensauken peneplain. Submergence carried the Pensauken waters up the basins of these streams as far as they had been peneplained, thus giving rise to a series of bays, separated from one another by the former divides between the streams. The southeast shore of the sound was therefore irregular (see Plate XII.), and along it there was much shallow water.

The waters of the sound worked over many of the incoherent beds of sand, marl, clay, etc., mixing them to a greater or lesser extent with one another, and depositing the materials again near the source whence they had been derived. The materials handled by the waters were doubtless shifted more or less along the coast line, and so disposed in their deposition as to diminish the irregularities of the coast. Materials were also doubtless transported more or less from the land toward the axis of the sound. The sound, therefore, was receiving deposits from two main sources—first, from the northwest, and, second, from the southeast. The line of deepest water was probably northwest of the middle of the sound, since that was the line of the greatest streams in the development of the pre-Pensauken peneplain. It is probable, too, that more material came to the sound from the northwest on account of the larger size of the streams coming in from that direction.

Now the material derived from these different directions differed in its constitution, being derived from very dissimilar formations. The approximate line to which material was brought from the northwest and from the southeast respectively is indicated on Plate XII. by the line *A B*. Southeast of a narrow belt, the general position of which is marked by this line, the Pensauken deposits were derived from the southeast. Northwest of it they were brought in from the northwest, while along it there is more or less mixture of materials derived from the two directions. The relative areas of Pensauken on the two sides of the line do not represent relative

volumes, for the formation was, on the whole, considerably thicker northwest of this line (averaging 15 to 25 feet) than southeast of it (averaging not more than one-third to one-half as much).

Generally speaking, the material of the Pensauken formation was coarsest near the shore, and finer and finer toward the line *A B*. It is notable, too, that the coarsest material is most abundant near the debouchures of the streams coming into the sound from the north.

The topographic effect of the deposition of the Pensauken formation was to even up the surface of the Pensauken peneplain. Many minor depressions in it were filled. The sharp and considerable depressions which seem to have been made in it just before the end of the pre-Pensauken erosion cycle (see p. 127) were obliterated. Some of the low elevations were buried, or made less conspicuous, by having the surrounding surface built up by the new deposits. At the end of the deposition, the bottom of the sound was a nearly level plain, with its lowest axis along the line *A B* (Plate XII.), and with very gentle slopes toward this axis from either side.

Of the Pensauken formation, along the Atlantic coast, it need only be remarked that it is made up of sediments of local origin, being derived from the Beacon Hill gravels and sands, or, to the north, from the Cretaceous and Beacon Hill. The formation is thin, and its effect on the topography of the border of the Coastal plain was not great.

SECTION VIII.

THE UPLIFT FOLLOWING THE PENSAUKEN. THE POST-PENSAUKEN CYCLE OF EROSION.

CHANGES IN DRAINAGE.

The deposition of the Pensauken formation was brought to an end, so far as New Jersey is concerned, by the uplift of the surface on which it had been accumulated. This uplift was sufficient to bring most of the southern part of the State somewhat above its present level. It was therefore more than sufficient to connect the island of southeastern New Jersey (see Plate XII., p. 130) with Pennsylvania on the west, and with the northern part of the State on the north. Thus the Pensauken sound was eliminated and the former geographic relations re-established. Along the line of the Delaware, the uplift seems to have been greater to the north and less to the south, though the difference was not great. In the vicinity of Trenton, the Pensauken surface was brought to an elevation of about 110 feet, while further south it was slightly less. Along that part of the sound running from Trenton to Raritan bay, the uplift was slightly greater to the northeast than to the southwest.

As a result of the emergence, the mouth of the Delaware river was transferred from the vicinity of Wilburtha to Delaware bay. This, the largest river concerned, became the master stream for all the drainage of the Coastal plain flowing to the northwest, and helped to determine their positions. It flowed southeast to Trenton and then turned in a southwesterly direction, following essentially the course which it possessed in the pre-Pensauken cycle. This course must have been chosen as a result of the slope of the Pensauken plain as it emerged from the sea. It would suggest that along an axis corresponding with the line x y (Plate X., p. 102)—a line which had probably been an axis of differential elevation at an earlier time—the uplift at this time was greater than to the northwest, thus determining the course of the Delaware. The excess of uplift along this axis necessary to turn the river to the southwest, below Trenton, would have been slight. With uplift along this line, the Delaware would have been obliged either to turn to the northeast to Raritan bay or to the southwest to Delaware bay. The former would have

been the shorter course, but the fact that it chose the latter shows that the greater slope was in this direction.

The bed of Pensauken sound (see Plate XII.) was nearly level when the sinking which brought it below sea level took place. During the period of submergence the surface was made still more nearly level by having its depressions, slight as they were, partially or wholly filled by the deposits of the Pensauken formation. As the bed of Pensauken sound emerged, it was therefore a plain, relieved only by very slight undulations. On either side of this plain there were streams in well-defined courses throughout the Pensauken period. As the bed of the sound re-emerged, these streams, on reaching the site of the former shore, were obliged to choose new courses across the newly-emerged and uneroded Pensauken plain.

The streams which had been tributary to the sound from the southeast during the time when the Pensauken formation was being accumulated, continued their courses to the Delaware. The courses which they at first chose may not have been, in all cases, the courses which they now possess, but the present courses are the original ones, modified by such adjustments as have been accomplished in later time.

Plate XIII. shows the drainage which established itself on the surface after the Pensauken emergence, as nearly as can now be determined. Those portions of the streams in full lines represent the portions which persisted throughout the period of Pensauken deposition, while the dotted portions represent the post-Pensauken portions.

Mr. Knapp believes that certain peculiarities of the streams in the region formerly covered by the Pensauken, find their explanation in the peculiarities of that surface at the time of its emergence. In the Pensauken sound, as already indicated, the chief deposition seems to have been on the northwest side, where the average depth of the formation is fifteen feet or more. On the southeast side the deposition was less, and along the line of junction of deposits made from the northwest and from the southeast respectively, slight depressions, due to the lack of filling, were sometimes left. On the emergence of the Pensauken surface these depressions are believed to have influenced some of the streams, causing them to assume courses which were not direct to the Delaware. In this manner, Mr. Knapp thinks, is to be explained the peculiar course of the south branch of Rancocas creek, the waters of which flowed to the northeast and then to the north, before joining the north branch, when a much more direct

course would have been to the west, via Pensauken or Cooper's creek, to the Delaware. Cooper's creek likewise has a branch from the south which might have found a more direct course to the Delaware by way of Timber creek. Timber creek also has its longer branch on the south side, and the same is true of some of the other streams in the same region. In the case of Rancocas creek, the stream which drained the same area in the pre-Pensauken cycle of erosion had a course similar to that of the present stream, and the depression then developed appears not to have been completely obliterated by the Pensauken deposition.

The streams along the southeastern and eastern side of the Coastal plain have been studied in little detail south of the Manasquan, but their general course would seem to have been as indicated on the map—that is, essentially as now.

The Raritan system.—The most considerable difference between the drainage of the post-Pensauken and pre-Pensauken cycles, as shown by a comparison of the drainage of Plate X. with that of the present time, lies in the Raritan system. On Plate XIII. the Raritan river is represented (doubtfully) as having assumed its present course. This would mean that after the union of the two branches of this stream on the emerged Pensauken surface, the waters found a line of easier escape to the eastward than to the southward by their former route. At the same time, if this view be correct, the headwaters of the Millstone, rising in the higher parts of the Coastal plain, flowed northwest across the Pensauken plain in the direction of slope; but instead of joining the Raritan south of Princeton, and flowing thence to the Delaware, as in the earlier cycle, it followed the old course of the Raritan to the north, joining the main stream as now, below Bound Brook. This course for the Millstone would mean that the rise following the deposition of the Pensauken formation was less along the present lower course of the Millstone than in the vicinity of Rocky Hill and the region to the south, for the Millstone flowed up the old valley of the Raritan.

The best reason for believing that the Raritan assumed its present course on the emergence of the Pensauken formation lies in the fact that a change at this time seems rational. Its channel from Somerville to Rocky Hill had been filled by the Pensauken beds, as also from Kingston to Trenton. It therefore was obliged to choose a new course across the Pensauken plain, and a trivial difference in uplift might have been sufficient to determine the new course to the east.

PLATE XIII.

EXPLANATION OF PLATE XIII.

Plate XIII. shows the drainage relationships as they are believed to have established themselves after the uplift following the deposition of the Pensauken formation. The areas where the streams are represented by full lines are the areas not submerged during the Pensauken period. The areas where the streams are represented by dotted lines are the areas where the Pensauken formation was exposed after the uplift which closed the epoch. The dotted streams were consequent upon the Pensauken surface.

If the Raritan changed its course at this time, its lower course should be that of a superimposed stream—that is, the stream should have taken its new course according to the slope of the Pensauken formation, without regard to the structure of the Triassic beneath. Now, the valley of the Raritan, from the point where it receives the Millstone to Raritan bay, has the characteristics of a valley developed by a superimposed stream. It is not in harmony with the structure of the rock, but runs in a course which is in complete disregard of it. But this can hardly be construed as an argument for the change in the course of the stream *at this time*.

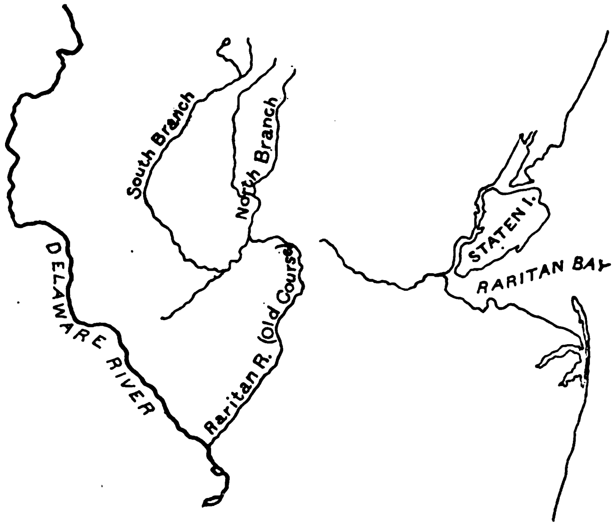


Fig. 28.

Diagram illustrating the alternative hypothesis concerning the change of course of the Raritan. The small stream flowing into Raritan bay has only to eat its head back into the land a short distance to capture the Raritan.

The alternative hypothesis concerning the Raritan seems to be that after the re-emergence of the Pensauken surface, it continued for a time to flow in its old course, via Rocky Hill to Trenton, but that a valley, developing headward from Raritan bay, worked back so as to tap the Raritan near the mouth of the Millstone and lead it off captive to the eastward. It would not be necessary to suppose that this robber valley was completely developed in post-Pensauken time. It might have been largely developed in pre-Pensauken time —that is, it may have been nearly ready to draw off the Raritan in this direction before the Pensauken submergence. During the period

of erosion following the deposition and emergence of this formation, this valley may have been re-excavated and enlarged, so as to accomplish that which had not been accomplished before. If this valley was originally developed on the surface of the Beacon Hill formation, as this hypothesis assumes, its stream would have been superimposed on the Trias, when the overlying formation had been cut through. The lack of adjustment of the valley to the structure of the shale is therefore not an argument for or against either hypothesis, as distinct from the other. Between these two hypotheses the evidence is not conclusive. On the whole, the former seems the simpler, but there are some meagre indications, which will be mentioned later, that the Raritan continued to hold its old course till a time much later than that now under consideration.

On the emergence of the Pensauken plain, the course of Manalapan creek departed widely from that which it now has. It probably flowed northward, to the vicinity of Lawrence brook, and from that point may have flowed down the present valley of that stream, or may at first have passed by way of Ten Mile run to the Millstone.

The degradation of the Pensauken formation began with the establishment of drainage upon it. So far as it was concerned, this was the first cycle of erosion. The uplift which closed the Pensauken period was also felt outside the area which had been covered by water during that period. The streams which had developed broad flats and plains in the pre-Pensauken cycle were rejuvenated by the elevation of their basins, and for them a new cycle of erosion was inaugurated. It was during this cycle that many of the minor topographic features of the State were developed.

POST-PENSAUKEN EROSION IN THE HIGHLANDS AND ON THE PIEDMONT PLAIN.

It was during the post-Pensauken erosion cycle that the sub-valleys 200 to 300 feet deep in the bottom of the Great Kittatinny valley (see p. 14), were worked out, transforming the flat plain of the previous cycle into the rolling plain of to-day. During this cycle, the streams of the Highlands, many of which, on account of the obduracy of the rock, had never developed wide valleys, continued to deepen their courses.

Much of the Triassic surface remained land during the Pensauken submergence, and on this the streams were at work while the Pen-

sauken was being deposited elsewhere. But with the Pensauken emergence these streams were quickened and lengthened, and entered upon a new period of activity. It was at this time that the streams between the Palisade ridge and First mountain cut out the minor valleys 100 to 150 feet deep below the level of the pre-Pensauken peneplain of the region (see Fig. 25, p. 106).

In the region where the Trias had been covered by the Pensauken—that is, along the northwest side of the old Pensauken sound—the history of the streams was somewhat different from that where this formation was not present. At the outset the streams took consequent courses upon the Pensauken plain, as already described, and as indicated on Plate XIII. (p. 136). But the Pensauken formation was thin, and the streams soon cut through it into the harder beds beneath, and thereupon began that series of adjustments which streams must always undergo, when, having cut through one formation, they reach a lower one and find themselves out of harmony with its slopes and structures.

It was during this period that the valleys in the Triassic area below the level of the pre-Pensauken peneplain were cut. Even considerable plains were opened out along the larger streams. Thus the Raritan developed a valley plain of great width between the point of union of its branches and New Brunswick, and its tributaries from the direction of Plainfield did a comparable work. The following profile, from north of the village of Raritan to near Middlebush, gives a better idea of the work of this cycle in the area of the Brunswick shales than description can, though farther from the main streams the erosion was less. The dotted line represents the pre-Pensauken peneplain, and the full line the present profile.

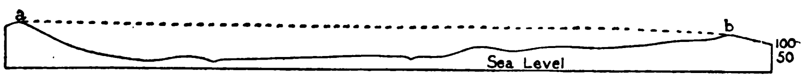


Fig. 29.

Profile from a point a mile north of the village of Raritan to a point near Middlebush, illustrating the amount of erosion accomplished in this region in the post-Pensauken cycle of erosion. The pre-Pensauken penelain is represented by the dotted line.

North of Rocky hill the few areas now rising to the 130-foot level about Franklin Park, East Millstone, Raritan, Finderne, New Durham, Plainfield, etc., have traces, and sometimes considerable beds of Pensauken gravel. These remnants represent the pre-Pensauken peneplain on which the Pensauken was deposited. The 140-foot hill

one and one-quarter miles east of Griggstown, and the 153-foot hill two miles east, both of which are capped by five to twenty feet of Pensauken gravel, and the 169 and 176-foot hills north of the Raritan, also capped by Pensauken, indicate something of the level of the Pensauken surface and something of the amount of degradation since the Pensauken submergence, and therefore in the post-Pensauken cycle of erosion. Most of the Pensauken deposited in the area between the Palisade ridge and First mountain, an area now covered by drift, was worn away before the invasion of the region by the ice of the last glacial epoch. If any remnants of it remained the ice itself destroyed or buried them. Only near its edge, at some points between Metuchen and Perth Amboy, does the last glacial drift overlie the Pensauken.

Between Princeton and Trenton Junction and Trenton, considerable remnants of Pensauken still remained at the close of the post-Pensauken cycle. The streams, such as Shipetaukin and Shabakunk creeks, had cut through the Pensauken and into the shale beneath, but the Pensauken was left on the divides. North of Rocky hill, and south of First mountain and the terminal moraine of the last glacial epoch, erosion was more successful in removing the Pensauken, so that by the close of this cycle there remained but a few isolated remnants of it, separated by broad stretches of bare Triassic shale, over which were scattered occasional pebbles and cobbles to mark the former presence of this formation. Not only was the Pensauken removed, but the well-developed pre-Pensauken peneplain beneath was so eaten into by erosion that but few remnants of it persist, except where Pensauken gravel-beds are found. The part of the peneplain north of Rocky hill differed from that to the south, in that the Pensauken formation had been mainly removed, and the Pensauken peneplain itself largely destroyed in the former region, while considerable areas of the formation remained in the latter.

The effect of the erosion of this cycle was the destruction of the flatness of the Pensauken plain-level, and its transformation into a rolling plain instead, but since the land was not high the relief developed was not great. The erosion period lasted sufficiently long to allow the streams to remove most of the Pensauken north of the Fall line, as well as much of it to the south, and to allow the larger streams to cut about as deeply into the soft Brunswick shales as the stand of the land permitted.

THE POST-PENSAUKEN EROSION CYCLE IN THE COASTAL PLAIN.

Further to the southeast, over all that part of the Coastal plain which had been covered by the waters of Pensauken sound, the streams found themselves on the Cretaceous beds as soon as they had cut through the Pensauken, and the history of the topography of the areas where the Raritan and Clay Marl beds outcrop, so far as it is post-Pensauken, is really the history of the adjustment, or attempted adjustment, of the streams to the Cretaceous beds beneath. The general facts concerning the structure of the Cretaceous beds have already been given (pp. 117–9). The area where the Raritan formation outcrops had been nearly base-leveled in the preceding cycle, and the post-Pensauken streams had only to cut through the thin veneer of Pensauken sand and gravel to find themselves superimposed upon it. Where the streams flowed upon the clayey portions of the Raritan, they cut their valleys less rapidly; where they found themselves upon the layers or huge pockets of sand their growth was rapid, and their valleys became wide. An illustration of a broad valley developed where the conditions were favorable, is found in Cheesequake creek, the valley of which is a mile wide, and no more than two and one-half miles long, and forty to seventy feet deep. Its great size is due to the fact that it was located on one of the huge sand pockets which affect the formation.

The diverse character of the various beds of the Matawan formation has already been pointed out (p. 118). This variety had influenced erosion in the preceding (pre-Pensauken) cycle, and at its close the surface where the Matawan formation outcrops was not regular, though most of it had been brought low. During the erosion of the post-Pensauken cycle, the irregularities were emphasized. Not only have the more enduring layers tended to develop into ridges, but they have influenced the character of the valleys, many of which are constricted where they cross the harder layers, and expanded where they cross the softer. Non-resistant layers of the Clay Marl or Matawan series were the occasion of the development of considerable flats, such as those in the vicinity of Mount Holly, Jobstown, and west of Imlaystown.

In some cases the Pensauken formation overlying the Clay Marl was exceptionally stony or gravelly, and so protected the underlying beds from erosion. This explains the origin of certain small hills

northeast of Manalapan creek along the outcrop of the sand layer in the middle of the Matawan series. To this class belong the hills near Hazlet, between Keyport and Port Monmouth, and between Matawan and Matchaponix.

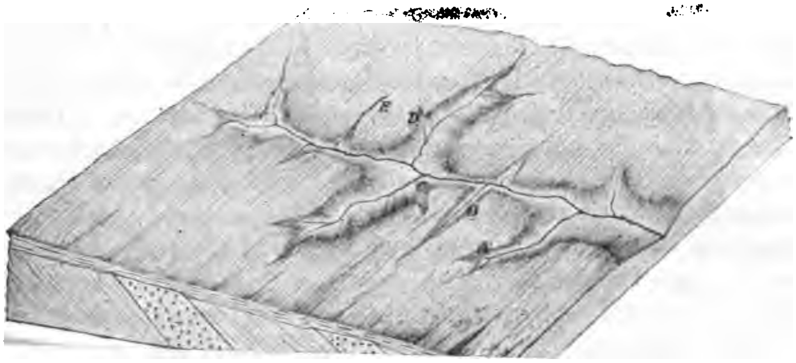
As already indicated (p. 118), the Marl series was more resistant than the Raritan or Matawan. The Red Sand and the base of the Middle Marl are the most resistant, and have given rise to the most marked elevations. Where the less resistant layers, like the upper part of the Middle Marl, come to the surface, flats were developed. It is in the outcropping area of this formation that the flats about Colt's Neck, Scobyville, Tinton Falls and Eatontown are located. The topographic relations of the several formations to one another are diagrammatically expressed in Fig. 27 (p. 120).

THE ADJUSTMENT OF STREAMS WITH REFERENCE TO CRETACEOUS STRUCTURE.

When drainage established itself (see Plate XIII., p. 136) on the emerged Pensauken surface, the streams took their courses without reference to the structure of the underlying Cretaceous. When they had cut through this formation into the Cretaceous beneath, each of them found itself, with reference to the Cretaceous, in one of three positions. It was, 1°, parallel to the strike; 2°, at right angles to the strike; or, 3°, oblique to it. In each of these cases changes were possible, though their nature and amount varied in the several cases. In the western part of the Coastal plain the Delaware river—the master stream—flowed in a course approximately parallel to the strike of the Cretaceous beds. Its tributaries—streams of the second order—flowed in a direction approximately, but not exactly, at right angles to it, and therefore across the strike, and that in a direction opposed to the dip. The tributaries to the tributaries—streams of the third order—were, like the Delaware, approximately parallel to the strike. The changes in these several classes of streams serve to illustrate some of the types of changes to which rivers are subject in the process of adjustment.

The changes undergone by the streams parallel with the strike are best illustrated by the changes in the streams of the third order, tributary to the Delaware. When such a stream found itself superimposed upon one of the softer layers, it lowered and widened its channel rapidly. Where it found itself superimposed upon a harder

bed, its channel was lowered less rapidly. The result was that the streams on the soft layers had the advantage of those on the hard, and robbed them of their waters. The inequalities of texture which operated in this way are found especially in the Matawan series, composed, as already noted, of alternating beds of marl, clay and



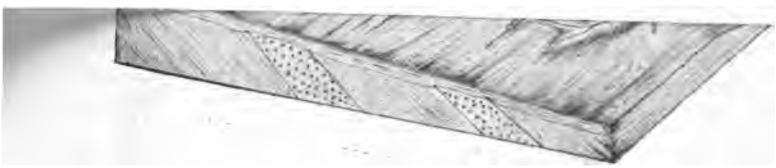


Fig. 31.
The same after adjustment.

sand, the latter being sometimes cemented. The series of changes and adjustments which would result under these circumstances is illustrated by the diagrams, Figs. 30 and 31. Fig. 30 represents drainage before, and Fig. 31 after adjustment. In the first figure, streams are represented as having taken their courses on the surface

in disregard of its substructure. This might be the case where the region had been submerged and a layer of unconsolidated material deposited over the surface where the outcropping layers are unequally hard. The streams *A* [redacted] and [redacted] flowing over more easily eroded beds than [redacted], excavate deeper valleys. Their tributaries worked back and rob [redacted] of its waters [redacted] The result of the adjustment is to get the streams off the hard layers on to the soft.

Even after the above adjustment had been accomplished, the streams continued to change their position, though not the direction of their courses. Flowing along the strike of dipping beds, streams do not usually sink their channels vertically, but shift them down dip at the same time that they are deepened. This process is known as monoclinal shifting. It is greatly facilitated if the layers of rock are of unequal resistance. The stream, once it enters the softer stratum, makes its way through it to a hard bed beneath if there be one within reach. When it has reached such a position, erosion is unequal on its two banks (see Fig. 32), and the stream shifts its position in the direction in which the beds decline.

One result of this monoclinal shifting is to give the valleys an asymmetrical cross-section, as shown in Fig. 32. In this figure the attempt is made to illustrate the processes of shifting, both as it is taking place, and after it has been long in operation. *r s* represents the present surface; *x y* the surface of the plain on which the stream took its consequent course after the Pensauken submergence, and z [redacted] *q* the Cretaceous surface beneath. Suppose the young streams to be located in the small valleys *a b* and *a′ b′*. At a later stage the valley *a b* will have been enlarged so that its cross-section is *c d*. By this time its base will have discovered the Cretaceous beneath, and monoclinal shifting begins. *e f* represents a further stage in the development of the valley, and asymmetry is beginning to appear. A still later stage is represented by *g h*. From this point on, there is relatively little erosion on the right-hand side of the valley, as seen in the section, while on the left-hand side the stream continues to lower and shift its bed. *h*, *i*, *j*, *k* and *l* represent the left-hand side of the valley at successive stages until the stream, after having traveled down the slope from *r*, reaches the position *m*. The stream which occupied the valley *a′ b′* underwent a similar series of changes until it reached the position *n*.

Since in a given region the beds dip in a constant direction, all the

streams parallel with the strike would be shifted similarly, and in the same direction, so that all have their steep slopes on the same side. In the Coastal plain the steeper sides of the valleys are commonly to the southeast (down dip) wherever the course of the streams is not at right angles to the strike. Thus in the valleys tributary to the Delaware, the steeper side is generally to the south or southeast; that is, in the direction of dip.

It is not to be understood that monoclinal shifting is the only cause of asymmetry in valleys, but it is perhaps one of the most common causes, and the one which has been chiefly operative in southern New Jersey.

Mr. Knapp has brought out the fact that the process of monoclinal shifting has given rise to certain other phenomena which are worthy of note. The stream developing the valley *c d*, Fig. 32, in the

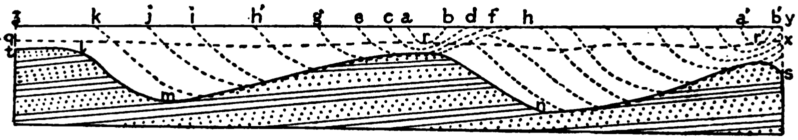


Fig. 32.
Figure illustrating monoclinal shifting.

Pensauken formation, probably had more or less gravel and sand in its channel. In places this is known to be the fact. When the monoclinal shifting began, some of the gravel and sand on the stream bottom was abandoned by the stream as it shifted down the dip, and was left as a protecting mantle on the Cretaceous slope, to the right of *m* and *n*.

Taking into account the shifting of the streams, the diagram shows that an early bed of the stream may later become the top of a ridge. The combined processes of deposition and shifting have in some cases resulted in the capping of the higher ridges between the streams with gravel which is not Pensauken, but Pensauken reworked. This process may also account for the faintly marked pseudo-benches or terraces that prevail on the long gentle slopes of many of the valleys.

The causes which produced monoclinal shifting in streams parallel to the strike would at the same time tend to bring the streams which were oblique to the strike into parallelism with it. The same result would also be facilitated by the processes which tend to get the streams already parallel with the strike off the hard layers and on to those

less resistant. Streams oblique to the strike, therefore, tended to work into parallelism with it. This change was more easily accomplished where the original course of the stream was nearly parallel with the strike, and less easily accomplished where the angle between the direction of the stream and the strike was greater.

After an oblique stream was brought into parallelism with the strike, it was subject to monoclinal shifting, the same as a stream the original course of which was in this position.

The tendency of the tertiary streams, or streams of the third order, to swing into parallelism with the strike, is illustrated by the tribu-

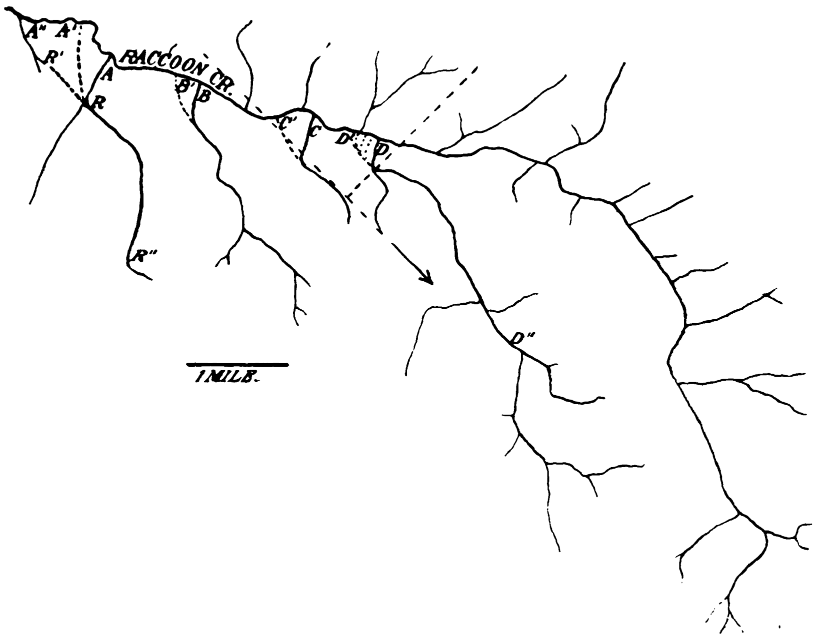


Fig. 33.
The junction of the tributaries of Raccoon creek with their main.

taries to Raccoon creek, shown in Fig. 33. The main stream is here at tide-level, and long since ceased to lower its valley. The lower ends of the tributaries turn so as to flow along the strike, and join their main at a right angle. In the figure, the dotted lines indicate the probable course of the streams before adjustment. The phenomena of Raccoon creek are repeated in Mantua creek, where Edwards run joins it, and in the lower course of the Chestnut branch, where it enters Mantua creek, just below Wenona. Similar phenomena, though to a less extent, are seen along Timber and Cooper's creeks.

Fig. 34 shows the same tendency manifested in a slightly different way along Pensauken creek. The south branch of this creek originally had an independent course to the Delaware through the Pachack, but a tributary of the north branch, heading back from *d*, Fig. 34, on one of the softer layers of the Cretaceous, made such headway that it captured the south branch and diverted it to the north. The present Pachack is therefore a beheaded stream, and the low pass along the dotted line, representing the abandoned course of the south branch, is merely a wind gap, inconspicuous because the region is so

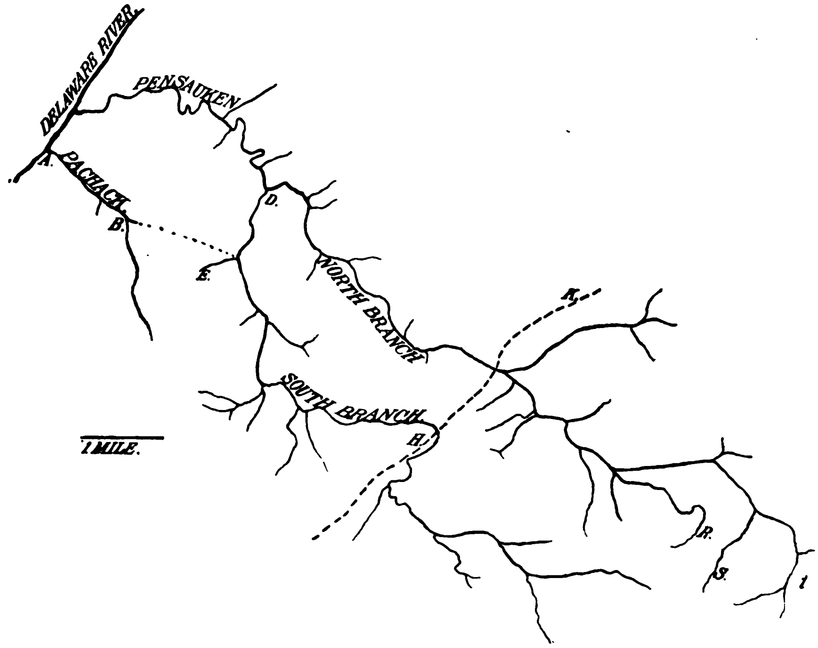


Fig. 34.
Drainage change in the Pensauken creek.

low and the pass so shallow. This diversion did not take place until well along in the post-Pensauken cycle of erosion, for the south branch flowed along *b c* long enough to cut through the Pensauken bed on which it took its consequent course, and in addition, twenty feet into the Cretaceous beneath, before it was diverted to the north.

The roundabout course of the south branch of the Pensauken above *h*, Fig. 34, is probably not the result of adjustment in this cycle, but is a consequent course along the line *H K* (corresponding with *A B*, Plate XII.), which represents the outcrop of one of the

harder layers of the Matawan series. This layer had formed a ridge during the pre-Pensauken cycle of erosion, but was thinly covered by the Pensauken beds at a later time. Southeast of *H K* the material of the Pensauken formation was derived from the southeast, and northwest of it, from the northwest. The area to the southeast was probably never built up so high as that to the northwest, so that after the Pensauken deposition was completed, the line of elevations along *H K* had not been completely obliterated. The streams which had their heads southeast of this line, therefore, followed it from the beginning. The headwaters of the north branch of the Rancocas are nicely adjusted to the structure, being rather exactly parallel to the strike. The branch *r* is in the uppermost bed of the Clay Marl, which is here easily eroded, while *s* is at the contact of the Lower Marl and the Clay Marl, and *t* is in the Lower Marl itself.

Farther northeast, in Black's creek, we have another instance of adjustment by diversion. Three miles southeast of Bordentown this creek turns abruptly to the southwest, following the strike of the Cretaceous, and joins Bacon's run, which offered an easier course to the Delaware. Black's creek originally joined Bacon's run two miles further down stream (Knapp), but was diverted by a tributary to Bacon's run, which cut back to Black's creek and offered the latter a lower route. Crosswicks creek and Timber creek show little tendency to adjust their courses to the Cretaceous structure, though some of their tributaries have shifted their courses, under the influence of the Cretaceous beds. The larger creeks are strong enough to persist in the courses which they took on the surface of the Pensauken, in spite of their partial lack of harmony with the Cretaceous structure beneath.

Many other examples of similar adjustment might be mentioned, but those given are sufficient to illustrate the principles involved. The processes involved in their adjustments were such as resulted in the more or less abrupt changes in the courses of the streams.

The streams of the Coastal plain directly tributary to the Delaware had, in general, courses which were west of northwest, while the strike is northeast-southwest. It follows that the process of the monoclinal shifting was operative to some extent in these valleys, and, moreover, was in the same direction in parallel valleys. It tended to make the left sides of the valleys the steeper, since this was the down-dip side. That the left-hand sides of the valleys are the steeper, has long been a matter of common knowledge.

The streams the courses of which were at right angles, or nearly at right angles, with the strike, suffered, as a rule, little change in their courses. Their tendency was to develop wider valleys where they crossed the more easily eroded beds, and narrower ones where the beds were more resistant.

The topography of the Coastal plain at the close of the post-Pensauken cycle was not very different from that of the present time. More or less extensive flats had been developed along many of the streams at levels somewhat lower than those of the pre-Pensauken cycle. The whole of the area which had been brought low in that cycle was not brought down to the new base plain, indicating that the post-Pensauken cycle was of less duration than that which had preceded.

Along the lower course of the Delaware, as far north as Camden, a wide plain bordering the stream was brought down nearly to base-level during this cycle. Here the streams tributary to the Delaware had widened their valleys until they became laterally continuous. Further inland the valleys were narrower, and, instead of being laterally continuous, they were still separated by interstream ridges. The plain next the Delaware was therefore bordered, on its inland side, by a dissected tract of upland, composed mainly of the Beacon Hill formation.

North of Camden, between Cooper's and Crosswicks creeks, the phenomena were somewhat different. Here there were, at the close of the post-Pensauken cycle, two fairly-distinct regions, each with a topography peculiar to itself. In a general way, the one region lay to the northwest of the line *A B*, Plate XII., and the other southeast of it. The region northwest of the line *A B* is the region, as already indicated, in which the Pensauken deposit was the deepest, and consisted of relatively-coarse material. It is also the region where the most resistant layers of the Matawan formation outcrop. These more resistant beds of the Matawan, with their capping of coarse Pensauken gravel, fitted this belt for resistance to erosion. On the other hand, the region southeast of the line *A B*, Plate XII., and northwest of the Marl Highlands, was the region where the less-resistant beds of Clay Marl came to the surface, and where the Pensauken covering was less well calculated to protect it. From these conditions it will be seen that the region northwest of the line *A B* was particularly unfavorable for erosion, while the region southeast of it was an easy prey to the streams.

It is therefore not surprising that at the close of the post-Pensauken cycle, the region southeast of the line *A B* approached topographic old age, an erosion base-level, whereas the region northwest of that line, notwithstanding the fact that it was nearer the Delaware—the master stream of the region—had only reached topographic maturity. Thus it came about that the upper courses of the Pensauken, Rancocas, Assiscunk and Crosswicks creeks developed wide plains, while the lower courses developed wide valleys only. The principle involved is the same that governed the development of the great flat lowland in the basin of the Upper Passaic. It is to this period that the broad flats between Moorestown and Marlton, Marlton and Medford, Medford and Pemberton, Pemberton and Brown's Mills, Mount Holly and Columbus, were developed. These flats are in the region which had been base-leveled in the pre-Pensauken cycle, and which was now for the second time brought essentially to a base-level, the later surface being about thirty feet below the level of the earlier.

Northwest of the tract where erosion had been so effective, and especially between Cooper and Crosswicks creeks, there was a region bordering the Delaware through which the streams from the southeast had cut broad valleys, but had not developed wide plains. On the interstream ridges and divides considerable areas of Pensauken gravel and sand remained at the end of the cycle, and, indeed, remain to this day. These are remnants of the Pensauken plain which subsequent erosion has failed to reduce. This belt of mature topography joins the area of greater topographic age to the southeast, by a tolerably definite line (near *AB*, Plate XII.) In places the former presents a scarp-like face overlooking the broad, flat lowlands of the latter, from which all the Pensauken has been removed, and above which only an occasional hill rises, and that not to the original Pensauken level.

Northeast of Crosswicks creek, the streams of the post-Pensauken cycle did not cut through the Pensauken formation soon enough or far enough to be so greatly affected by the Cretaceous structure beneath. This may have been because they had a more roundabout course to the sea. Especially would this seem to apply to the Millstone, if it had its present course through Rocky hill, and thence northwest across the Triassic terrane. The greater hardness of the Trias, as compared with the Cretaceous and Beacon Hill, also tended to keep the stream from lowering its channel so rapidly as the creeks

to the southwest. As a result the region northeast of Crosswicks creek, as far as Manalapan creek at least, showed, at the close of this cycle, less striking differences in topography on opposite sides of the line *A B*, Plate XII. But even here there was manifest a tendency to open out broad flats below the pre-Pensauken peneplain level to the southeast of the line *A B*, as in the vicinity of Imlaystown, about Disbrow's hill and west of Bergen's mill.

At the close of the post-Pensauken cycle of erosion, there was less relief in that portion of the Millstone basin which lay on the Cretaceous than to the southwest. The streams had cut deeply enough, however, to be influenced by the Cretaceous structure, which gave many of them steep slopes on one side and gentle slopes on the other.

The adjustment undergone by Manalapan creek early in the Pensauken cycle has already been noted. It was then that it abandoned its course through Rhode Hall towards Dean's Station and turned northeast at Jamesburg along the strike, being led off in this direction by a stream working back from the northeast along a line of easy erosion. By the close of this cycle Manalapan creek had developed for itself a broad valley northeast of Jamesburg, and its tributaries from the south, being situated where the easily-eroded Clay Marl outcrops, had likewise acquired extended valley plains.

The explanation of the northward turn of Manalapan creek—or its continuation, South river—at Old Bridge, where it leaves the direction of strike and flows across it to Sayreville to join the Raritan, is probably to be found in the history of Tennent's brook. At the beginning of this cycle this brook took its course upon the Pensauken plain in consequence of its slope. Its lower course probably corresponded with the course of South river below Old Bridge. After trenching the Pensauken, it discovered, in the incoherent sand immediately below the Clay Marls, a line parallel with the strike along which a side stream could develop with rapidity. This side stream captured the Matchaponix creek, and later the Manalapan itself. The volume of water thus acquired was much greater than that of the original creek.

In the vicinity of Matawan, except the capping of a few isolated hills, the Pensauken had been removed and the region had been reduced to maturity or nearly to old age, by the close of the cycle. This region stood about forty feet lower than now, and the streams had sunk their valleys fifty to sixty feet below the Pensauken plain,

and had developed wide flats at that level. The topography at the close of the cycle was much the same as that of the present time, except for the sharp, trench-like valleys of the present streams. These are of later origin.

Along the eastern border of the Coastal plain, Swimming (Navesink) river, and all the rivers to the south, developed valleys and plains comparable with those on the west side of the State, tributary to the Delaware. The surface here had been less perfectly evened up by Pensauken deposition, and the streams held their pre-Pensauken courses through valleys which had been but partially filled. The erosion work which they accomplished in the post-Pensauken cycle appears to be less clearly separable from that accomplished in the preceding cycle, than along the western and northern sides of the Coastal plain.

Some idea of the amount of erosion in the Coastal plain in this cycle may be obtained by the study of the figures in Plate XI.

SECTION IX.

TOPOGRAPHIC CHANGES DURING AND SINCE THE LAST GLACIAL EPOCH.

A. IN THE GLACIATED TERRITORY.

The post-Pensauken cycle of erosion had been long in progress, carving out sub-valleys in the bottom of the great Kittatinny valley, and in the depressions between the Palisade ridge and First mountain, deepening the valleys of the Highlands, dissecting the pre-Pensauken peneplain in the Triassic belt, and developing valleys and valley plains in the Coastal plain, when the ice of the last glacial epoch invaded the northern portion of the State. The topographic changes effected by the ice were not great, but, small as they are, in contrast with the boldness of the features due to the underlying rock, they yet produced great changes in the general appearance of the surface.

The topographic effects of the ice were twofold—1°, those produced by erosion, and, 2°, those produced by deposition. The ice affecting New Jersey at this time was the edge of the great ice-sheet, and was therefore less powerful as an eroding agent than in many other localities. Nevertheless, it achieved results of some importance, for, while it did not destroy mountains, or even hills of much size, it did destroy to a considerable extent their rugosities of surface, leaving them with softer contours and smoother outlines than they had before possessed. At the same time, the ice passing through the valleys, especially those parallel with its movement, deepened them, and smoothed their sides and bottoms. So far as erosion is concerned, the ice obliterated none of the considerable valleys and none of the considerable hills or ridges. Erosion alone being considered, it is doubtful if glaciation decreased at all the relief of the northern part of the State.

Had the drift which the ice deposited been disposed uniformly over the surface, it would have had but trivial effect on the topography. Its average thickness in New Jersey is probably not more than fifteen feet, and this, uniformly disposed over a region the relief of which is several hundred feet, would alter its general features scarcely at all. But the disposition of the drift was far from uni-

form. In some places the rock was left bare, while in others the drift is scores of feet in thickness. By its inequality of distribution, therefore, the drift deposited by the ice gave rise to many minor topographic features.

In general the valleys received heavier deposits than the uplands. This was true, both of the deposits made by the ice itself and of those made by the streams issuing from it. In general, too, low lands, as contrasted with high, received more than their share of drift. Thus the drift filling in the low area between the Palisade ridge and First mountain, and on the plain south of these elevations, as far as Perth Amboy, is much more considerable than on an equal area in the Highlands. The result both of the filling of the valleys and of the disproportionate building up of the low lands was to diminish the relief of the glaciated area. While, therefore, the erosive work of the ice may not have diminished relief, the deposition of the drift did, and there can be no doubt that the aggregate topographic result of erosion and deposition, was the reduction of relief in the region affected. But this reduction was accomplished by the filling of the depressions rather than by the lowering of the elevations. It is not to be understood, however, that the changes effected were great.

The irregular disposition of the drift gave rise to minor topographic features of types which are in marked contrast with those produced by erosion. The depressions produced by stream erosion have, as their diagnostic marks, one end lower than the other, or than any point above; that is, they have outlets. But in the irregular disposition of the drift, depressions without outlets—basins—were often developed. This was liable to happen almost anywhere, but especially in valleys. Thus if a valley received a large amount of filling at two points with a lesser amount of filling between, the result was a depression without an outlet. This is the first condition for the formation of a lake or pond, and this is the way in which the basins of many of the ponds and lakes of northern New Jersey arose.*

Again, the filling of a valley at one or more points was sometimes complete. Above the position of the filling, which served as a dam, a pond or lake came into existence, the water accumulating until it rose to the level of some new outlet. Such was the origin of the extinct Lake Passaic,† though in this case it was ice, rather than drift, which

* For a statement as to the origin of lake basins of New Jersey, see Annual Report of the State Geologist for 1894, pp. 85–91.

† See Annual Report for 1893, p. 225.

at first blocked the normal course of drainage. When the ice retreated, however, it left sufficient drift in the valley across the Second mountain at Summit to prevent the drainage resuming its former course via Summit and Millburn (see p. 52). This outlet having been closed, the waters rose to the level of the next lowest outlet. While the ice was in existence this was at Moggy Hollow (see Fig. 4, p. 5), west of Liberty Corner, and for a time the upper Passaic basin drained by this outlet to the Raritan. When the ice retreated sufficiently far, the waters of the lake found a lower line of escape *via* Little Falls and Paterson. It was not until this time, after the departure of the last ice-sheet, that the Passaic took its present roundabout course. Not only were the middle and lower courses of the Passaic changed at this time, but even its headwaters were compelled to make a long detour. Instead of following the more natural course, from the Great Swamp directly east, they were forced to flow west before they could get east, for the great terminal moraine left by the ice between Morristown and Chatham completely blocked drainage in that direction, and the waters from the Great Swamp found this lowest exit across Long hill and thence by this present circuitous route to the sea. That is, the narrow gorge through which the Passaic crosses Long hill, started and largely cut by some subordinate stream in an earlier (probably pre-Pensauken) cycle, was, at the close of the glacial epoch, lower than any point in the moraine on the northeast side of the Great Swamp, and the moraine between Long hill and Second mountain was likewise lower than at any point between Long hill and Morristown.

North and east of the moraine, in the great flat between the Second mountain and the Highlands, the drift deposits are heavy, and probably determine many of the low divides. What the course of preglacial drainage was in this area is not known, and probably cannot be determined.

The course of the Black river was probably reversed by the drift, and there were other minor changes in the drainage effected by the ice and the deposits which it left on its retreat, but they are not of great importance from the standpoint of topography. Many of them were mentioned in the annual report for 1894 (pp. 81–85), to which reference may be made. In spite of all these changes, it may still be said that with the exception of the Passaic, and possibly the Raritan (see p. 5), the larger streams continued to flow along the lines established before the advent of the last glacial epoch.

The reasons for the general immunity from change in the case of most of the streams of northern New Jersey may be readily pointed out. In the first place, most of the valleys of the glaciated portion of the State were parallel, or essentially parallel, to the direction of ice movement. In this position, glacial erosion tended to emphasize them, rather than to make them less marked. Had their courses been at right angles to the direction of ice movement, or even oblique to it, the disturbing influence of the ice would have been much greater. In the second place, most of the valleys were deep. The considerable elevation of the region, together with its mature drainage, had determined this point. Deep valleys are less readily obliterated, either by erosion or by filling, than shallow ones. In the third place, the rock in which they were cut is, on the whole, hard, and hard rock yields to the erosion of glaciers much less readily than soft. Deep valleys in soft rock would stand much better chance of obliteration, other things being equal, than corresponding valleys in hard rock. In the fourth place, the thickness of the drift over most of northern New Jersey is rather slight, so slight as to fail to fill the valleys which preglacial and glacial erosion had excavated. When the ice receded, therefore, the valleys still remained, and along them drainage re-established itself. Had the thickness of drift been great, the result might have been different. The hardness of the rock had something to do with the paucity of the drift. Lastly, the terminal moraine, which represents the thickest belt of drift in the State, crosses few of the important drainage lines. For these reasons, the larger pre-glacial valleys, with the exceptions already noted, are also the post-glacial lines of drainage.

B. IN THE SOUTHERN PART OF THE STATE.

After the long period of time involved in the post-Pensauken cycle of erosion, the southern part of the State, if, indeed, not all of it, sank to a slight extent, bringing the surface a little lower than it had been and considerably lower than it now is. The depression appears to have taken place before the close of the last glacial epoch, but the stage of the epoch at which it began, and at which it reached its maximum, are not known. While the ice of the last epoch was at its maximum, the streams flowing out from it were flooded, and brought southward heavy burdens of gravel, sand and silt. These

materials were deposited along the Delaware, along the Musconetcong and along Green brook, in the vicinity of Plainfield, aggrading their valleys.

Material of glacial origin likewise came up the Millstone valley from the vicinity of Bound Brook as far as Rocky hill, but whether the Raritan, still following its earlier course, carried it to this position in the early part of the glacial epoch, or whether it was carried there by the sea water after subsidence had formed a narrow strait along the line of this valley, is not known. The amount of glacial material along this valley is not great. Before the close of the glacial epoch, the southern part of the State appears to have sunk so as to convert the lower course of the Delaware into a sort of estuary. Into this the Delaware emptied in the vicinity of Trenton, and there spread out a great plain of gravel and sand, washed down from the moraine at Belvidere. The fact that some glacial gravel, and that rather coarse, was carried much further south by the Delaware, suggests that the subsidence did not take place until after glacial drainage affected the Delaware, and therefore not long (if at all) before the ice of the last epoch was at its maximum.

Coincident with the submergence of the lower course of the Delaware, the lower courses of its tributaries were also submerged. Along them, flats of sand, gravel and loam were deposited, and the levels of these flats correspond with the level of the deposits along the Delaware itself. It was at this time that the 60-foot plain of gravel about Trenton and Chambersburg, extending northeast to Baker's Basin, was developed. It was at this time also that the 30 to 40-foot plains of sand and loam about Burlington, Florence and Kinkora, and the conspicuous plain at Salem, now at an elevation of 20 to 30 feet, were developed. The 40-foot terraces about the south shore of the Raritan bay are referable to the same time, and much of the low-lying belt about the coast, ranging from 30 to 50 feet in elevation, was shaped at the same time. This low plain is partly the result of deposition and partly the result of wave-work on an older and less flat surface. Deposition was the chief process in the south—Cape May county and its surroundings—and cutting was the more important at some points on the east shore.

There is much reason to believe that near the close of the glacial epoch, or perhaps just after its close, there was a brief and somewhat deep submergence, which resulted in the deposition of a thin layer

of loam and sand over regions which until this time had been out of water since the deposition of the Pensauken formation. The extent of the submergence is not certainly known. Its limit is marked by no shore line, and the deposits made are so trivial in extent in many regions, and so much like the underlying formations, that their differentiation is difficult and often impracticable. In spite of all difficulties, there is reason to believe that in the vicinity of Plainfield and Somerville the surface below the level of 150 feet has been submerged since the glacial epoch.

This last glacial submergence did not result in notable changes of topography. The most considerable changes were in the submerged parts of the valleys, where there was filling, sometimes on a considerable scale. Elsewhere the amount of deposition was too slight to do more than thinly mask the topography which had developed in the post-Pensauken cycle of erosion.

During this time the thin mantle of material deposited over the Coastal plain was so disposed that on the emergence of the land, the surface was marked by numerous shallow basins * or sinks two to five, rarely ten feet deep. These sinks are usually but a few rods across, but they sometimes cover several acres. They are best developed where the deposition of this time was most extensive. In some places they appear to have been formed by the interrupted filling of shallow valleys, the places between the fillings remaining as hollows. These shallow depressions have given rise to numerous marshes, rarely to ponds. It is by no means certain that all of them were connected in origin with the submergence here referred to.

In the emergence which followed this last submergence, the State appears to have risen rather higher than it had stood in the immediately preceding epoch, perhaps higher than it had stood at any preceding time. With this rise, areas were added to the land which had before been continuously submerged, as far as is now known. This appears to be true especially of considerable areas in the extreme southern part of the State.

The principal modifications of topography since this last emergence have consisted in the partial re-excavation of the valleys which had been aggraded, leaving more or less of the filling along their sides in the form of terraces. In this manner arose the terraces of the Delaware and of many other lesser streams. In some cases the streams

* See Annual Report for 1894, pp. 124-6.

have not only sunk their channels through the filling made at this time, but still lower into the Cretaceous, or Beacon Hill beds below; but the time has been so short, and the altitudes of this part of the State so slight, that the streams have not developed great valleys. The time since this last elevation, compared with the time during which the post-Pensauken (and pre-glacial) cycle of erosion was in progress, is very short. The period of erosion in the post-Pensauken cycle, compared with that of the pre-Pensauken cycle, was likewise short. The time involved in the pre-Pensauken cycle, compared with that involved in the Cretaceous cycle, was likewise short. The series, from the Cretaceous on, is a diminishing one.

C. CHANGES EFFECTED BY THE WIND.

In the foregoing pages the shaping of the topography of the State has been attributed to two sets of forces, those of diastrophism and those of gradation. The forces of diastrophism have caused the land to rise and sink, and the forces of gradation have tended to cut the land down after its elevation. Diastrophism, to the extent of converting marine sedimentary beds into land, was the necessary condition for the process of gradation. These two sets of forces have been the most important in shaping land surfaces, not only in New Jersey, but throughout the world. The only other forces of the first importance are those of vulcanism, which has played no direct part in shaping the surface of our State. Indirectly, through gradation, the igneous rocks—the trap-sheets—have been responsible for certain well-defined topographic features.

Running water is the most important agency of gradation, and its influence on the physical geography of the State has already been discussed. The effects of glacier ice, the next most important agency of gradation, have also been referred to. There is still another agency, the wind, which has affected the surface of the State widely. Over most of its area, the topographic results which the wind has produced are not important; but in many places and over considerable areas its work is obvious, while in certain limited districts it has been the chief force concerned in the development of existing topographic forms.

North of the Coastal plain.—North of the Coastal plain, the obvious work of the wind is confined to a small class of situations. In

some areas the upper portion of the drift was deposited by the waters issuing from the melting ice, rather than by the ice itself, and is composed chiefly of sand. Such deposits are found especially on those valleys which served as avenues of drainage for the waters of the last glacial epoch. Blowing over such bodies of incoherent sand after it became dry, the wind frequently shifted some of it from the position in which it was left by the glacial waters. A few examples may be cited.

In the valley of the Delaware, much sand was deposited below the moraine while the ice stood in the vicinity of Belvidere, and above the moraine while the ice was receding from its position of maximum advance. Subsequently, after desiccation, the wind blew some of the sand up from the valley bottom to the slopes and bluffs above. Since the prevailing direction of the wind is westerly, the sand was carried to the eastward, and the slopes to the Delaware, on the New Jersey side of the river, are often mantled with a thin layer of wind-blown sand. This may well be seen near Lambertville below the moraine, and at several points above the Water Gap. Nowhere along the Delaware north of the Coastal plain is the amount of sand shifted by the wind sufficiently great to have affected the topography in an important way, though it locally determines the character of the soil.

The valley of the Black river was affected by glacial drainage, and some of the sand deposited in its bottom was subsequently blown up on the east slope of the valley, where it is now found mantling the crystalline schists and the soils which arose from their decay. The sand deposited by the wind on the side of this valley is nowhere more than a few feet in depth, and is, therefore, nowhere an important factor in determining the shape of the present surface. Blown sand also occurs at many points on the east side of the Passaic river, south of Paterson, and on the east side of the Hackensack.

There is likewise wind-driven sand in sufficient quantity to be distinctly noticeable along the east side of the Millstone, in the vicinity of the village of the same name, as well as farther north and south. In this case, as in the preceding, the sand concerned was first deposited by water during the last glacial epoch, and subsequently shifted to its present position.

The broad depression between the Palisade ridge on the east and the Watchung mountains on the west was the site of extensive deposits of sand during the closing stages of the last glacial epoch.

Some of this sand has since been driven by the wind up the west slope of the Palisade ridge, but its quantity is usually not sufficient to have influenced the topography of the slope in any important way. Locally, however, it has been heaped up into small dunes, which, in their flat surroundings, are conspicuous topographic features. Small but distinct dunes occur south of West Bergen, on the east side of Newark bay, and there is more or less wind-driven sand, sometimes in the form of small dunes, along the whole of the eastern border of this bay. Dunes also occur a little south of Hackensack, on the west side of the river, where they reach a maximum height of forty feet. These examples may serve to illustrate the general class of positions in which the wind-driven sand is to be found in the northern part of the State.

Much of the sand here referred to was probably blown to its present position soon after the close of the glacial epoch, or perhaps even during its closing stages. Subsequently, when vegetation had taken possession of the surface of the drift, the blowing of the sand must have been greatly checked, if not stopped. Since cultivation of the soil began, destroying the native vegetation, and leaving its surface altogether unprotected during some part of the year, the wind has again become effective in shifting sand and dust.

While wind-deposited sand is chiefly confined to special situations, no such restrictions are to be placed on the finer material which the wind has blown about. The blowing of dust is well-nigh universal in regions not thickly covered with vegetation throughout the entire year. It would probably not be an exaggeration to say that there is not a square foot of land in the northern part of the State from which or to which dust has not been blown; but, in general, the amount of material thus shifted has been so slight, or the two processes of deposition and removal have been so nearly balanced in any given region, that the topography has not been seriously affected.

In the Coastal plain.—In the Coastal plain the influence of the wind on topography has been more considerable. The surface formations of this part of the State are composed in considerable part of sand. When they were first lifted above the sea and subjected to desiccation, the wind doubtless blew the loose materials about to some extent before the surface was clothed with vegetation. Whatever influence the wind had in shaping the topography of the Coastal plain after the successive uplifts preceding the last, has since been ob-

literated or remains undistinguished, so that specific examples of the results achieved by the wind in the early part of the history of the Coastal plain cannot now be pointed out.

So soon as vegetation covered the surface, the wind must have ceased to be an effective agent of transportation. Subsequently, as valleys were cut in the Coastal plain, their slopes, while still unclothed with vegetation, furnished new sources whence sand might be blown. In so far as streams, in the course of their development, deposited sand in their valleys, it likewise was subject to drifting by the wind, before the growing vegetation had covered it with a protecting mantle. As a result, eolian sand is common along valleys the slopes of which are largely of sand, and along valleys in the bottom of which sand has been deposited by streams. It is probably not too much to say that sand has been blown up, or part way up, at least one slope of every valley in southern New Jersey, where the flood plain is of sand. In many cases the blown sand amounts simply to the facing of one slope of the valley with a few feet of eolian material, as in the cases already referred to in the northern part of the State; but in some cases the sand has been accumulated in greater quantity, and now appears in the form of low ridges or hillocks on the edge of the upland surface below which the valley has been sunk.

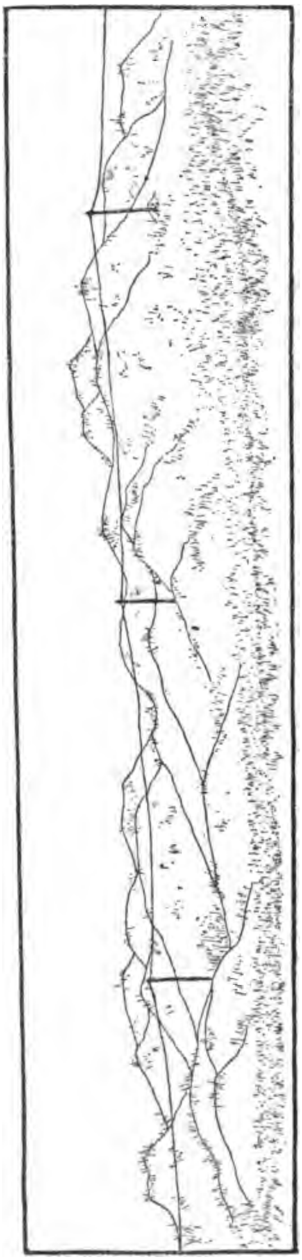


Fig. 35.
Dunes on Seven Mile beach.

There are few valleys in the Coastal plain in such a stage of development that loose sand, unprotected by vegetation, is now exposed on their slopes for any considerable distance. On the other hand, there are not a few valleys in the bottom of which sand is now being deposited in times of flood. From the flood plains of some of the streams, therefore, sand is now being blown to the slopes and low bluffs above. As in the northern part of the State, cultivation of the soil, where it is sandy, has greatly enhanced the work of the wind in shifting sand. Furthermore, the deforesting of sandy tracts, even where the soil has not been cultivated, has greatly increased the effectiveness of the wind as an agent of transportation. What with the deposition of sand on the flood plains of the streams, the cultivation of sandy soils, and the deforesting of certain tracts of sandy land which is not brought under cultivation, the wind was probably never more effective than now in shifting sand and dust.

From what has been said, it follows that eolian sand is most likely to be seen in quantity along the valleys of the streams. Thus along the lower course of the Delaware it is found in larger or smaller quantity along the immediate bluff overlooking the valley, much of the way from Trenton to Camden, and even farther south. As now disposed, the sand often serves simply to build up the edge of the bluff, raising it by the amount of the thickness of the sand above the general level of the upland of which the bluff is the edge. Thus at many points the surface of the upland fronting the valley is two, three, four or five feet higher than the surface behind it. Locally, the amount of sand blown on the bluff is much greater, so that, as at Florence, distinct hillocks and ridges are produced. While well-marked dunes along the Delaware are rare, the surface of the east bluff within the limits mentioned very generally shows the influence of wind, which, in addition to raising the edge of the bluff, has produced many of the low swells and ridges, together with the shallow depressions intervening. The swells and intervening depressions are often so well marked as to give the surface a distinctly, if but gently, undulatory surface. Such a surface may be well seen just north of Burlington, as well as at many other points along the railway between Bordentown and Camden. Part of the eolian sand along the Delaware was probably deposited somewhat as it now lies soon after the desiccation of the fluvio-glacial sands; part of it dates from a later time, after the development of the present valley flat, from which the

sand was blown; while still a third part has been brought to its present position and relations since the occupancy of the region by civilized men.

Along many of the tributaries to the Delaware, wind-blown sand has also been accumulated in similar positions. Locally, as near Birmingham, on the Rancocas creek, it has assumed the form of low dune ridges. Similar ridges may be seen along a few other streams in similar situations. In general, the dune sand is much more likely to be found on the south than on the north side of the valleys tributary to the Delaware. In the valleys of the streams flowing in other directions, less sand seems to have been deposited as a rule, and cultivation of the soil is less general. It follows that the work of the wind has been correspondingly less effective.

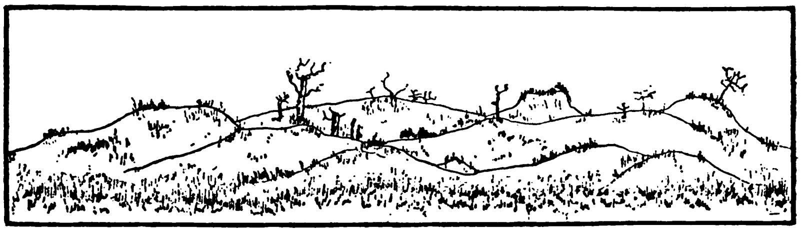


Fig. 36.
Dunes at Peermont.

Wherever, in the processes of degradation, incoherent layers of sand were exposed, they became a prey to the winds; and wherever such layers now appear at the surface, especially if free from forests, the effect of the wind is apparent, though it has not usually produced topographic features of great importance. In some such situations there are many small dunes, which, though their height is not great, give a distinct expression to the topography. The areas east of Old Bridge, and about Evesboro (northwest of Marlton) and Hammonton may be mentioned as examples. The surface about the last-named village may serve as an illustration of changes which would be likely to take place on an extensive scale were the forests of southern New Jersey to be destroyed. Since most of the forested area is more sandy than the country about this village, the effect of the wind would be more striking.

In but a single class of situations, namely, along the "beaches" (p. 60), has the wind produced effects which are topographically im-

portant. The sand of the beaches, washed up by the waves above normal water level in recent times, quickly became subject to the action of the wind which has heaped it up into the sharp ridges and hillocks, ten, twenty, thirty and even forty feet in height, which abound along the coast. The hillocks are often numerous and near one another, and it is their aggregation which gives the characteristic topography to the beaches of the coast. The dunes attain their greatest development between Atlantic City and Cape May, but they are also conspicuous farther north on Long Beach and Sandy Hook. As first fashioned, dune ridges and hills usually have gracefully-curved outlines, and smooth, regular slopes. But no sooner is a dune

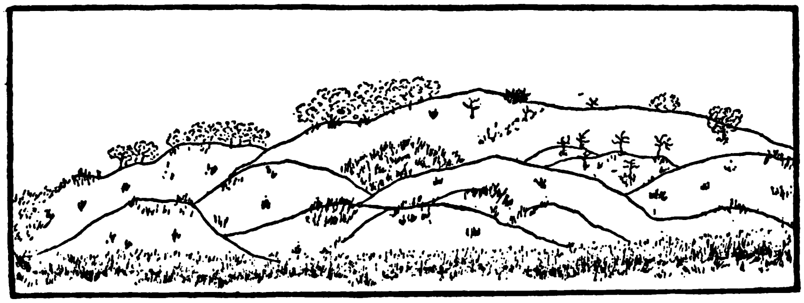


Fig. 37.
Dunes on Seven-Mile Beach, two miles north of those shown in Fig. 35.

hill made than the same force which made it, working from some other direction, or with different strength, or under different circumstances, begins to tear it to pieces, and move its materials to new positions. With the destruction go angular and irregular outlines and profiles. Since destructive and constructive processes go on together, it follows that most stretches of dunes show some hillocks which are perfect in association with others which have been half destroyed. Figs. 35, 36 and 37 and Plate XIV. represent characteristic dune forms. The last is a dune view near Longport, some miles below Atlantic City; the figures are a series of sketches representing the irregular and angular outlines characteristic of dunes which have suffered partial destruction.

SUMMARY.

The succession of events involved in the development of the present topography of the State may be summarized as follows:

1. *The post-Triassic uplift and the development of the Schooley peneplain.*—After the deposition of the Triassic formation there was a widespread uplift, affecting at least the northern portion of New Jersey, as well as the country adjacent on the west, north and northeast. Neither the area of the State which emerged from the sea after this uplift nor its altitude is now known with accuracy, but the northern part of the State, including all north of the Coastal plain, appears to have been elevated to a considerable height. During and after the uplift, erosion was operative on the land surface for a very long period of time, and it was brought essentially to base-level. This was the *Schooley peneplain* of Davis, or the *Kittatinny base-level* of Willis. This erosion appears to have been accomplished chiefly in Jurassic and early Cretaceous time. The development of this plain may be regarded as the first step in the genesis of the present topography. Whatever events preceded have not left direct record of themselves in the topography, though they have in the rocks themselves.

2. *The Cretaceous subsidence and deposition.*—After the development of the Kittatinny base-level, its southeastern portion was depressed to such an altitude that deposition succeeded erosion on its southeastern border. The formations then laid down, at first fresh and later marine, are known as the Cretaceous formations. This subsidence, resulting in the deposition of the Cretaceous beds, was the second event in the development of the topography of the State.

3. *The post-Cretaceous uplift.*—Following the deposition of the Cretaceous formations, there was a period of uplift, though it was perhaps of slight extent. As a necessary result of this uplift, the northern edge of the Cretaceous formations, occupying the central and north-central portions of the State, and the older formations farther north, were subjected to erosion. The record of the erosion of this interval is not now clear. This was the third, and, so far as now known, relatively unimportant, event in the topographic development of the State.

4. *The Miocene submergence and the deposition of the Miocene and Beacon Hill formations.*—Following the post-Cretaceous emergence

which may or may not have brought the southern part of the State above the sea, there was a period of depression which allowed the sea to again cover considerable areas which had been land since the uplift which followed the Cretaceous. During the submergence, Miocene beds were deposited wherever the sea existed. If the Beacon Hill formation be Miocene, it represents the last stage of deposition during this period of submergence. If the Beacon Hill formation be later than Miocene, the record of the intervening interval has not been deciphered. The Miocene and Beacon Hill formations probably extended farther north than the Cretaceous had done, covering all of that formation, and farther north resting on the Triassic, and possibly on still older formations. This was the fourth event in the history of the present topography of the State.

5. *The post-Beacon Hill emergence and the development of the pre-Pensauken peneplain.*—Following the Beacon Hill submergence, the land was again elevated and subjected to prolonged erosion. It was during this interval that the great Kittatinny valley, the great valley between the Palisades and the Orange mountains, and the extensive areas of lowland on the Triassic formation, were chiefly developed. Large areas south of the exposed border of the Triassic formation, within the area of the Beacon Hill, Miocene and Cretaceous, were likewise reduced nearly to sea level, and constituted, at the close of the period, what has been described in the preceding pages as the pre-Pensauken peneplain. Other considerable areas escaped such reduction. It was during this interval that the larger topographic features of the Coastal plain were developed. This was the fifth in the sequence of events here summarized.

6. *The Pensauken submergence and the deposition of the Pensauken formation.*—The next event of importance was a slight subsidence, affecting at least the central and southern parts of the State, and allowing the sea to encroach upon the preceding land surface, and to cover much of the pre-Pensauken peneplain. During this submergence the drowned areas were covered by the thin Pensauken formation. If at the same time the ice of an early glacial epoch occupied the northern part of the State, it left no topographic record which is now known.

7. *The post-Pensauken uplift and the erosion accomplished between this uplift and the last glacial epoch.*—Elevation succeeded the Pensauken submergence, and the uplifted Pensauken beds, as well as all

other exposed formations of the State, were subjected to erosion. A large part of the Pensauken was carried into the sea, so that over considerable areas only small remnants remain. This period of erosion was, however, much less long than most of those which preceded. During it many of the lesser features of the Coastal plain were fashioned. This constituted the seventh event in the history of the topography of the State.

8. *The last glacial epoch.*—The post-Pensauken period of erosion had been long in progress when the ice of the last glacial epoch invaded the northern part of the State, covering the area north of an irregular line, the ends of which, so far as New Jersey is concerned, are at Perth Amboy on the east, and a little below Belvidere on the west. During the glacial epoch the topography of the area affected was modified both by the erosion accomplished by the ice and by the drift which it deposited. These modifications were relatively slight, and the great topographic features of the northern part of the State remained much as before.

At about the same time there was a slight submergence in the southern part of the State, depressing its borders up to elevations of thirty to fifty or sixty feet beneath the sea. It was during this period of depression that the 30–45-foot terrace about much of the coast was developed. It is possible that there was a brief interval of greater submergence at this time, affecting a wider area. This was the eighth event affecting the present topography of the State.

9. *Post-glacial elevation.*—Subsequently the land was elevated to something like its present height, and the deposits made by the ice and by the sea water on the area submerged during or immediately after the glacial epoch were subject to erosion. The interval since this elevation has been so slight that great changes have not been accomplished. The most conspicuous result is the excavation of the Delaware valley below the terraces of glacial drift. During this time, also, the wind has been active, bringing into existence the sand dunes which now affect the surface of some parts of the State.

APPENDIX.

NOTES AND DATA PERTAINING TO THE PHYSICAL GEOGRAPHY OF THE STATE.

BY C. C. VERMEULE.

NOTES AND DATA

PERTAINING TO THE

PHYSICAL GEOGRAPHY OF THE STATE.

GEOGRAPHICAL POSITION.

The northernmost point of the State is Tri-States rock, at the forks of the Delaware and Navesink rivers, just south of Port Jervis, New York. It is in latitude 41 deg. 21 min. 22.6 sec., and longitude 74 deg. 41 min. 40.7 sec. The most easterly point is in the middle of the Hudson river nearly opposite Hastings, New York, and due east from the terminal monument of the State line on the west bank of the river. This point is in latitude 40 deg. 59 min. 50.1 sec., and longitude 73 deg. 53 min. 39 sec. Cape May is the southernmost point of land, and lies in latitude 38 deg. 55 min. 40 sec., and longitude 74 deg. 56 min. 40 sec. In the middle of the Delaware river, just above Pea-patch island, and in latitude 39 deg. 37 min. 00 sec., and longitude 75 deg. 35 min. 00 sec., lies the most westerly point.

The extreme length of the State from Tri-States rock to Cape May is 166 miles, and its narrowest part is at a line drawn from Trenton to Great Beds light-house, in Raritan bay, which is 33½ miles long. The portion lying north of this line is nearly square, measuring about 55 miles from northwest to southeast, and 65 miles from the New York line southwest to the Delaware river. The Delaware forms the northwest and southwest boundaries of this square, the New York and New Jersey line between Tri-States rock and the Hudson the northeast side and the Hudson river, New York bay, Kill van Kull and Arthur Kill the southeast side. This line makes a natural dividing line between northern and southern New Jersey, and marks a decided change in topographic and other physical features. Southern New Jersey measures 36½ miles in width from Bordentown to the

seashore, and gradually increases to 57 miles from opposite Chester, Pennsylvania, to Great Egg Harbor inlet. Its length from Raritan bay to Delaware bay is just about 100 miles. Excepting on the above-described line from Trenton to South Amboy, this portion of the State is surrounded by water.

BOUNDARIES.

New Jersey is bounded for a distance of 108 miles on the north and east by the State of New York; for 137 miles on the east by the Atlantic ocean; for 78 miles on the south and west by the State of Delaware, and for a distance of 164 miles on the west by the State of Pennsylvania. Her total frontier measures 487 miles, of which all but 48 miles is defined by natural boundaries—rivers, bays and the ocean.

This area was first constituted and named as a distinct colony or province in the year 1664, when it was sold by James, Duke of York (afterwards King James II.), to Lord Berkeley and Sir George Carteret. In the deeds of lease and release, dated respectively 23d and 24th of June, 1664, it is described as "That tract of land adjacent to New England, and lying and being to the west of Long Island and Manhitas Island; and bounded on the east, part by the main sea, and part by Hudson's River; and hath upon the west, Delaware Bay or River; and extendeth southward to the main ocean, as far as Cape May, at the mouth of Delaware Bay; and to the northward as far as the northernmost branch of the said bay or river Delaware, which is in 41 deg. 40 min. of latitude; and crosses over, thence, in a straight line, to Hudson's River, in 41 deg. of latitude; which said tract of land is hereafter to be called Nova Cæsarea, or New Jersey."*

This description led to long controversies as to the location of the northern boundary, for subsequent examination showed that there was no important fork of the river Delaware near latitude 41 deg. 40 min. The eastern extremity of the boundary was first determined to be at the mouth of Tappan creek, afterwards it was claimed that it properly began opposite the mouth of Spuyten Duyvil creek, and still other claims were presented for its location at various points between these extremes. The western end of the boundary was proposed by

* Leaming & Spicer, p. 10.

some to be fixed at the head of Delaware bay, and by various others at the mouths of the Lehigh, the Navesink, the Popaxtun and the Mohawk branches of Delaware river, and at the lower end of Minisink island. Many attempts were made to reconcile these conflicting claims and to ascertain and mark the line.

The commission appointed in 1767, to determine the northern boundary, decided that this description had been based on a map of the period, the errors of which account for the vagueness of the description. This map was published shortly before the above grant was made, and it bears a marked resemblance to one published by Van der Donck in his "Description of the New Netherlands as it now is," 1656. It is known as Visscher's map. Its latitudes are about one-quarter of a degree too great at the northern boundary.

This grant clearly includes Staten Island. This, however, was early claimed as a part of New York and her title to it was finally confirmed by the action of the Legislatures of the two States and of the Congress of the United States, in 1834.

Various commissions have been appointed since 1718 to fix different portions of the State boundaries, but the work is still incomplete. For convenience the following brief descriptions of the State boundaries are given, as near as at present known:

Territorial Boundaries.

Beginning at Tri-States rock, at the forks of the Delaware and Navesink rivers, the line between New York and New Jersey runs southeast, changing its course slightly at the end of each mile, so that at Greenwood lake it swerves southward 2,415 feet from a straight line joining its two ends, so continuing to the terminal monument on the west bank of Hudson river opposite Hastings. The line is marked by a granite monument at each highway and railroad crossing, and also at the end of each mile as measured from the bank of the Hudson. Thence the line runs east to the middle of Hudson river, and then down the middle of the said river and New York bay to a point about five-eighths of a mile southeasterly from Robbins' Reef light-house; thence westerly along the middle of Kill van Kull to the northward of Shooter's island, and down the middle of Arthur Kill to a point at the mouth of said Arthur Kill. From here it follows a straight line to Great Beds light; thence on a straight line

toward Waacake light until it intersects a line from United States Coast and Geodetic Survey station "Morgan 2" through Romer stone beacon; and thence on the same line until it intersects a line drawn from Sandy Hook beacon to United States Coast and Geodetic Survey station "Oriental Hotel," on Coney Island; thence on a line at right angles to this last-mentioned line to the open ocean. Down the coast the boundary is a line three geographical miles from the coast line until we reach a line drawn through the middle of Delaware bay; thence up the middle of the bay and river * to the line between Pennsylvania and Delaware. The line between New Jersey and Pennsylvania follows thence up the middle of the Delaware, leaving the several islands of said river to the State nearest which they lie, to Tri-States rock, the place of beginning.

Limits of Jurisdiction.

The above bounds limit the property rights of the State. In some cases they coincide with the jurisdictional limits, and in other cases they do not. The limits of jurisdiction follow the line from Tri-States rock to the Hudson river as described above; thence due east to the middle of said river, and following the middle of the river to a point opposite the mouth of Spuyten Duyvil creek; thence westward to low-water mark on the western shore of the Hudson. Jurisdiction is limited by low-water mark of the western shore from this point southward along the river and New York bay to Kill van Kull, and changes as the shore line is changed by improvements. Continuing, the limits follow the north shore of Kill van Kull and the west shore of Arthur Kill to the mouth of Woodbridge creek; thence crossing the Kill and following low-water mark of the Staten Island shore around to Prince's Bay light-house. From here they follow a line drawn from Prince's Bay light-house to the mouth of Matavan creek, until said line intersects the previously-described line of territorial limits drawn through the middle of Raritan bay; thence along said line to the ocean, and down the coast to a point midway between the Delaware capes. From here New Jersey claims jurisdiction to the middle of Delaware bay and river as far up as the line between Delaware and Pennsylvania. From this point north-

* This is New Jersey's claim. It has been disputed by the State of Delaware. See Revised Code of Delaware, 1874, chap. 1, sec. 2.

ward to Tri-States rock the States of New Jersey and Pennsylvania exercise joint jurisdiction over the waters of the Delaware river, offenses being tried in that State which first apprehends the offender.

The right to regulate fisheries extends to the property limits so far as the question has been settled by inter-state compacts.

The above description embodies the best understanding which can be reached of the results of the various inter-state commissions.

LATITUDE AND LONGITUDE OF GEODETIC STATIONS.

The following table has been prepared from published reports of the United States Coast and Geodetic Survey, from manuscript furnished by that organization, from work done for the same survey by Acting Assistant Prof. E. A. Bowser, aided by Prof. A. A. Titsworth, and from a minor triangulation covering about one hundred and fifty stations, executed during the prosecution of the Topographical Survey of the State.

These stations have been utilized in the Topographical Survey and are located with marked accuracy.

The primary stations are printed in small capitals in the table. So far as it can be done without interfering with other details, the points are shown on the sheets of the Topographical Atlas, and parties wishing to find them should consult these maps first.

Many of the points are prominent spires, chimneys or other structures which may be readily found by any one; many others are marked by conspicuous stone monuments; some only by buried marks; while still others were never permanently marked, being only intended for immediate use by topographical parties. Many of the older points have not been found during the prosecution of the Topographical Survey; these are followed by an interrogation point (?). Some of these were located near enough for topographical purposes by witness-marks, etc., without the actual station-mark being recovered, while others were utilized through the medium of United States Coast and Geodetic Survey plane-table sheets. As a rule, the stations will be found upon the highest or most commanding ground in the vicinity.

The name by which the station is known to the Survey is first given; this is followed by a short description as full as space permits; and, as the description will often be unintelligible without, it is followed by the date of selecting or determining the point. When this

is not exactly known, the date of the report in which it first appeared is given; thus (a. 1851) signifies that the point antedates 1851, etc. Those determined since 1875, by Prof. Bowser, are indicated by (B.) Those determined by the Topographer of this Survey are marked (V.)

The stations are arranged by counties geographically. Under each county the older points, computed on the Bessel spheroid, are given first. Following these, under the heading *Clarke's Spheroid*, are the later points computed from the latest and best data as to shape and size of the earth, and with corrected telegraphic longitudes. Many of the stations in the first list are repeated in the second. At the head of the second list under each county, in the columns of seconds, are given the average differences of latitude and longitude between the two lists. Any one desiring the latest and most accurate locations, correct to one-tenth of a second, should add these quantities to the figures in the list preceding. This should always be done when the stations are to be used for constructing maps.

The total number of points utilized in making the Topographical Survey of the State is 457. Excluding the close tertiary triangulation along the Hudson and Delaware rivers and the sea-coast, they average one to each 25 square miles. In one or two cases where unusually large intervals occur between stations, the topography has been laid down by means of transit traverses.

Table of Geographical Positions.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
ATLANTIC COUNTY.	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Bessel's Spheroid—						
Leeds' Point. ½ mile S. of hotel (?) (a. 1851)	39	28	58.63	74	25	39.63
Little Egg Harbor Light. (a. 1851)	39	30	18.41	74	16	48.02
Brigantine Beach (?) (a. 1851)	39	25	48.98	74	19	37.01
Absecom. On point, 1 mile S. E. of Absecon village (?) (a. 1851)	39	25	08.55	74	29	06.57
Peter's Beach. 1 mile N. E. of Absecon Inlet (?) (a. 1851)	39	23	16.50	74	24	01.60
Risley's Landing. On Lake's Bay (?) (a. 1851)	39	22	48.75	74	31	11.49
Dry Inlet (?) (a. 1851)	39	20	31.28	74	27	57.42
Leedsville. Near edge of upland, E. of Linwood. (a. 1851)	39	20	52.82	74	33	19.98
New Inlet (?) (a. 1851)	39	19	08.49	74	30	30.65
Somers' Point (?) (a. 1851)	39	18	38.78	74	35	02.95
Clarke's Spheroid. Difference			*+03.7*			*+20.3*
Oyster Creek (?) (1867)	39	30	27.04	74	24	35.04
Leeds' Point (?) (1867). (See above)	39	29	02.37	74	26	00.00
Absecom (?). (See above.) (1867)	39	25	12.43	74	29	27.03
Ryon (?) (1867)	39	22	45.09	74	31	33.70
Absecom. Light-house. (1867)	39	21	58.74	74	24	52.27
Leedsville (?) (1867)	39	20	55.88	74	33	39.42
Grove (?) (1867)	39	20	03.74	74	30	17.18
Linwood (?) (1867)	39	20	54.06	74	33	38.76
Fish (?) (1867)	39	18	39.50	74	32	34.26
Somers' Point (?) (1841)	39	18	41.90	74	35	22.46
Somers (2) (?) (1867)	39	18	42.68	74	35	23.39
River. (1883)	39	18	23.07	74	37	12.11
Ocean. (1883)	39	17	18.69	74	34	13.14
New Inlet (?)	39	19	11.58	74	30	50.17
HAMMONTON. Stone monument on hill, S. side of C & A. R. R., 1¼ miles N. W. of village	39	38	48.05	74	49	19.29
BLANGIE. Stone monument on summit, 2¾ miles N. E. of May's Landing. (B.)	39	28	44.36	74	41	16.71
RICHLAND. One mile S. E. of village, 200 yards west of R. R. (B.)	39	29	18.96	74	51	12.59
Elwood. (B.)	39	34	40.33	74	42	55.55
New Germany. (B.)	39	36	26.48	74	50	49.07
Weymouth. (B.)	39	31	02.18	74	46	48.46
Doughty's Tavern. (B.)	39	26	53.96	74	51	46.69
Elwood. Spire. (V.)	39	34	40.3	74	42	55.6
Weymouth. Stack. (V.)	39	30	23.5	74	46	36.0
Richland. On hill, 1 mile S. E. of village. (V.)	39	29	19.0	74	51	12.6
New Germany. Spire. (V.)	39	36	26.3	74	50	49.2
Doughty's. Flag north of tavern. (V.)	39	26	54.0	74	51	46.6
Buena Vista. Flag opposite R. R. station. (V.)	39	30	50.6	74	55	29.7

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
ATLANTIC COUNTY—Continued.	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Russia. Flag. (V.)	39	22	46.2	74	48	32.9
Estellville. (V.)	39	22	21.4	74	45	44.1
Miry Run. (V.)	39	23	26.5	74	41	35.6
English Creek. (V.)	39	22	18.3	74	39	18.3
Egg Harbor. Church spire. (B.)	39	31	46.41	74	38	22.75
Port Republic. Church spire. (B.)	39	31	11.33	74	29	33.97
Hammonton. Church spire. (B.)	39	38	16.42	74	48	04.36
BERGEN COUNTY.						
Bessel's Spheroid—						
Cherry Hill. N. of Highland, on hill (?)	40	54	43.31	73	57	52.37
Banta. Summit of Hackensack and Teaneck road (?)	40	53	09.94	74	00	39.66
Terhune. Hill W. of Corona (?)	40	51	38.11	74	04	36.76
Bury. Hill N. of Carlstadt	40	50	26.17	74	05	02.57
Vreeland. At Ridgefield cross-roads (?)	40	49	58.12	74	00	19.67
Kingsland. On ridge, ½ mile S. of village (?)	40	47	45.16	74	07	12.75
DIDERY. Yonkers, N. Y.	40	57	59.98	73	50	13.95
Bald Mountain. Summit Ramapo Mountain, ½ mile S. of State line. (B.)	41	07	11.94	74	11	43.11
Ramsey's. Church tower. (B.)	41	03	31.01	74	08	12.30
Wykoff. Church cupola. (B.)	41	00	25.13	74	10	06.18
Allendale. Church spire. (B.)	41	01	46.96	74	07	14.94
Paramus. Church spire. (B.)	40	59	04.52	74	05	13.48
Hackensack. Church spire. (B.)	40	53	15.95	74	02	12.85
Palisade. (B.)	40	59	50.33	73	53	57.69
Englewood. (B.)	40	53	25.56	73	57	56.25
Bergen Fields. Church spire (B.)	40	55	43.04	73	59	53.38
Coytesville. (B.)	40	51	34.99	73	58	25.47
Schraalenburg. Church spire. (B.)	40	56	22.48	73	59	20.53
HIGH TORNE. Summit, 1 mile N. of Ramapo, N. Y. (B.)	41	09	02.79	74	09	27.53
Clarke's Spheroid. Difference			*+02.6*			*+19.8*
PIERMONT. N. Y.	41	02	57.26	73	55	38.52
DIDERY. Yonkers, N. Y.	40	58	02.57	73	50	33.88
BUTTERMILK. N. Y.	41	06	36.44	73	48	38.90
Bury. Hill N. of Carlstadt	40	50	28.80	74	05	22.41
Fort Lee flag-staff	40	50	49.00	73	57	53.76
State Line, New York and New Jersey. Stone on bank of Hudson river	40	54	50.10	73	55	28.95
Duer. N. Y.	40	59	53.46	73	54	10.37
Darlington. E. edge of Ramapo Mountain. (V.)	41	04	42.7	74	12	32.8
Ramsey's. Church tower. (V.)	41	03	33.6	74	08	32.2
Wykoff. Church spire. (V.)	41	00	27.7	74	10	26.0
Paramus. Church spire. (V.)	40	59	07.1	74	05	33.4
Midland Park. Church tower. (V.)	40	59	26.8	74	08	31.6
Schraalenburg. Church spire. (V.)	40	56	25.1	73	59	40.5

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
BURLINGTON COUNTY.	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Bessel's Spheroid—						
Bordentown Observatory. (1840)	40	09	17.57	74	42	24.14
Bordentown flag-pole. (1840)	40	08	49.95	74	42	29.99
White Hill (?) (1840)	40	08	19.49	74	43	33.66
STONY HILL. Buried cone, with locust post at surface, on hill 1 mile S. of Ellisdale. (1840)	40	07	09.59	75	34	33.06
Clay banks (?) (1840)	40	07	11.49	74	47	33.41
King (?) (1840)	40	01	18.05	74	56	10.10
MOUNT HOLLY. Granite monument, top of mount. (1840)	40	00	06.12	74	46	59.70
Arney. Summit of 'Arney's Mount (?) (1840)	40	00	25.66	74	41	53.02
Woodside (?) (1840)	40	03	44.52	74	49	14.43
Moorestown spire. Episcopal Church. (1840)	39	57	42.27	74	56	42.09
Evesham. Summit of Mount Laurel (?) (1840)	39	56	00.45	74	53	20.81
Rancocas (?) (1840)	40	02	33.10	74	58	20.84
Washington Hunter (1) (?) (1840)	40	00	52.51	74	58	48.73
Washington Hunter (2) (?) (1840)	40	00	52.73	74	58	57.20
Tuckerton. Near edge of upland E of village (?) (a. 1851)	39	36	06.69	74	19	27.59
Cedar Hummock. On a well-known small island in the marsh, 2½ miles S. of Tuckerton (?) (a. 1851)	39	34	07.05	74	20	19.06
Clarke's Spheroid. Difference			*+03.0*			*+19.6*
Collegeville, Pa. (?) (1878)	40	02	44.22	75	01	01.96
Partridge, Pa. Jack Island, bank of Delaware. (1878)	40	03	16.62	74	58	33.33
Delanco Church spire. (1878)	40	02	58.11	74	57	25.15
Delanco. Bank of Delaware at village. (1878)	40	02	46.15	74	57	46.20
Harrison's house cupola, Pa. (1878)	40	02	22.67	74	59	47.93
Pennypack, Pa. (?) (1878)	40	02	11.35	75	00	00.32
Hawk. S. W. end of Hawk Island, Riverside. (1878)	42	02	35.95	74	58	39.21
Fisher, Pa. Fisher's wharf, S. of Torresdale (1878)	40	02	37.01	74	59	15.71
Plum. At water-edge on Plum Point. (1878)	40	01	56.99	74	59	26.61
Saint Vincent's School cupola, Pa. (1878)	40	01	21.10	75	01	53.09
House of Correction flag-staff, Pa. (1878)	40	01	43.63	75	00	58.73
House of Correction chimney, Pa. (1878)	40	01	48.94	75	01	04.44
Ten-Mile Point, Pa. (1878)	40	01	26.06	75	01	04.88
Tacony water tower. (1878)	40	01	42.92	75	02	41.24
Tacony. Methodist Church spire, Pa. (1878)	40	01	23.92	75	02	34.55
South's house cupola, Pa. (1878)	40	01	26.18	75	02	24.01

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
BURLINGTON COUNTY—Continued.	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Bristol. Stone at Bristol street and Delaware avenue, Bridesburg, Pa. (1878)....	39	59	22.64	75	04	13.22
Washington. Washington street and Delaware avenue, Tacony, Pa. (1878)........	40	01	07.64	75	02	11.75
Disston's flag-staff, Tacony, Pa. (1878).....	40	01	07.15	75	02	14.71
Disston's chimney, Tacony, Pa. (1878).....	40	01	05.93	75	02	23.04
Fitler's chimney, Pa. (1878).................	40	00	39.22	75	03	36.95
Frismuth. On river bank, S. end of Riverton. (1878).................................	40	00	45.49	75	01	27.16
House of Correction, Tacony, Pa. Near S. corner of wharf. (1878)....................	40	01	30.72	75	00	52.76
Hunter's house. N. chimney of Clayton Cole's house, 1½ miles S. E. from Riverton. (1878).....................................	40	00	47.91	74	59	07.46
Lenning's round chimney, Pa. (1878)......	40	00	21.34	75	03	40.29
Bridesburg, Pa. S. W. corner of Bridesburg wharf. (1878)...........................	40	00	02.75	75	03	42.51
Lenning's square chimney, Pa.................	40	00	15.74	75	03	36.57
Van Kirk. Van Kirk street, 370 feet S. E. of N. W. side of Delaware avenue, Bridesburg, Pa. (1878)......................	40	00	33.06	75	03	21.12
MOUNT HOLLY. Granite monument on top of the mount. (1840)....................	40	00	09.10	74	47	19.35
APPLE PIE HILL Stone monument on summit of hill, 3 miles S. W. of Shamong R. R. station. (1871).................	39	48	26.62	74	35	23.83
Tuckerton. (See above.) (1866)............	39	36	10.16	74	19	47.82
Cedar Hummock (2). (See above.) (1866)..	39	34	10.58	74	20	39.31
MARTHA. Stone monument on summit, 2¼ miles E. of Martha Furnace. (B.)...	39	40	35.87	74	28	13.12
Bordentown. Baptist Church spire. (V.)..	40	08	48.7	74	42	50.1
Bordentown. Presbyterian Church spire. (V.)..	40	08	36.5	74	42	37.1
Crosswicks. Spire. (V.).....................	40	09	16.3	74	39	02.1
Florence. Foundry chimney. (V.)........	40	07	31.1	74	49	05.6
Burlington. St. Mary's spire (V.)..........	40	04	37.8	74	51	43.6
Bishop's barn. E. of Columbus. (V.)......	40	03	47.4	74	41	38.0
Columbus. West spire. (V.)..................	40	04	25.0	74	43	31.4
Taylor's Mount, S. of Gookstown. (V.).....	40	02	03.6	74	33	01.9
Lewistown. Wind-mill. (V.)...............	39	59	26.9	74	37	11.7
Smithville. Mill tower. (V.)................	39	59	10.7	74	44	54.7
Brown's Mills. (Observatory.) (V.)........	39	58	09.5	74	34	53.3
Mt. Laurel. (Summit.) (V.)..................	39	56	03.5	74	53	39.3
Marlton Church tower. (V.)..................	39	53	26.3	74	55	10.7
Medford. (V.).....................................	39	54	55.3	74	51	13.5
Retreat. Hill, 1½ miles S. E. of schoolhouse. (V.)......................................	39	53	52.2	74	41	47.7
Huckleberry Hill. 1¾ miles N. W. of Tabernacle. (V.)..............................	39	51	24.5	74	44	15.7
Four Mile. At cross-roads. (V.)............	39	53	08.7	74	34	11.6

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
BURLINGTON COUNTY.—Continued.	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Taunton Hinchman's store cupola. (V.)..	39	51	12.1	74	51	21.4
Jemima Mount. 2½ miles E. of Quaker Bridge. (B.)	39	42	42.95	74	37	04.06
Sharp's Mount. 3½ miles west of Indian Mills. (B.)	39	48	04.68	74	48	39.17
Plains flag. Woodland township. (B.)	39	49	12.35	74	25	46.97
Bear Swamp. Hill 1 mile N. E. of Penn Place. (B.)	39	45	08.02	74	27	57.26
Spring Hill. 2 miles N. of Penn Place. (B.)	39	46	15.84	74	27	58.43
Batsto flag. On tree in village. (B.)	39	38	36.08	74	38	54.82
Herman. Glass works chimney. (B.)	39	37	04.20	74	35	58.96
Crowleytown. Church spire. (B.)	39	36	56.82	74	37	21.79
CAMDEN COUNTY.						
Bessel's Spheroid—						
Fishcove (Hatchis) (?) (a. 1851)	39	58	20.87	75	03	33.67
Wood's Point (?) (a. 1851)	39	57	25.27	75	05	19.23
Walnut Street Ferry (?) (a. 1851)	39	56	34.08	75	07	27.22
Kaighn's Point (?) (a. 1851)	39	55	42.89	75	07	33.04
Cooper's Point (?) (a. 1851)	39	57	12.58	75	07	22.69
Haddonfield. Hill 1 mile S. of village (?) (a. 1851)	39	52	50.37	75	02	03.80
Gibbsboro (?) (a. 1851)	39	50	17.57	74	56	39.88
PINE HILL. Granite monument N.W. brow of hill, ½ mile S. of Clementon. (1840)..	39	47	51.03	74	59	16.50
Morris Hill (?) (a. 1851)	39	59	21.78	75	02	17.26
Camden Church spire. (a. 1851)	39	56	41.06	75	07	10.19
Gloucester Point (?) (a. 1851)	39	53	46.11	75	07	27.36
Fish Club flag staff (?) (a. 1851)	39	53	13.54	75	07	24.32
Powder Wharf (?) (a. 1851)	39	54	10.47	75	07	43.73
Mickle (?) (a. 1851)	39	54	37.24	75	07	02.97
Girard College, Philadelphia, Pa. (a. 1851)	39	58	23.58	75	09	54.09
State House spire, Philadelphia, Pa. (a. 1851)	39	56	52.61	75	08	41.90
Clarke's Spheroid. Difference			*+03.0*			*+19.5*
Frankford Pumping Station ch'y, Pa. (1878)	40	00	50.61	75	02	51.83
Frankford Catholic Church cross, Pa. (1878)	40	00	42.48	75	05	25.03
Horner. Buried terra-cotta pipe, 800 yards N. E. from Camden Water Works and 150 yards back from river bank. (1878)	39	57	40.85	75	05	42.31
Jenks. Jenks street and Delaware avenue, Bridesburg, Pa. (1878)	39	59	52.82	75	03	53.26
Morris (2). On hill just E. of Morris R. R. station. (1878)	39	59	23.70	75	02	36.51
Tioga (2), Pa. S. W. butting pile, end of Elevated R. R. track, Gas Works wharf, Tioga street, Philadelphia. (1878)	39	58	45.36	75	05	14.26

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
CAMDEN COUNTY—Continued.	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Fairview. Terra-cotta pipe, buried 170 feet N. E. of Hatch Bros.' brick-yard chimney, E. side of R. R. cut, Fish House station, (1878)	39	58	28.13	75	03	56.89
Pike, Pa. Pike street and Delaware avenue. (1878)	39	59	05.80	75	04	45.48
BERLIN. Stone monument, on summit, 2 miles N. E. of village. (B.)	39	48	55.85	74	54	45.07
Haddonfield. White spire. (V.)	39	53	59.3	75	01	45.7
Atco. Richards' house cupola. (V.)	39	46	17.7	74	53	08.2
Atsion. Mill tower. (V.)	39	44	21.5	74	43	30.6
Waterford. Spire. (V.)	39	43	23.9	74	51	09.4
Merchantville. East spire. (V.)	39	57	00.6	75	02	57.0
Atco flag, S. W. side C. & A. R. R, 1½ miles from Berlin station. (B.)	39	46	44.83	74	54	15.92
PINE HILL. Same as above	39	47	54.09	74	59	36.09
Phladelphia. Tower of City Hall. (B.)	39	57	09.62	75	09	50.35
CAPE MAY COUNTY.						
Bessel's Spheroid—						
Stipson (?) (1842)	39	11	51.41	74	54	18.31
Ludlam's Landing. N. side of Dennis Creek (?) (1842)	39	10	38.46	74	50	50.00
McCrea (?) (1842)	39	09	49.32	74	50	26.09
Goshen (?) (1842)	39	07	36.35	74	53	10.93
Pierce's Landing (?) (1842)	39	04	54.33	74	54	05.78
Fishing Creek (?) (1842)	39	01	04.08	74	56	32.26
Higbee (?) (1842)	38	57	14.12	74	57	31.95
Cape May Old Light-house. (a. 1851)	38	55	48.64	74	57	38.90
Cape May New Light-house. (a. 1851)	38	55	50.42	74	57	15.57
Congress Hall. (a. 1851)	38	55	51.01	74	55	09.77
Week's Landing (?) (1851)	38	58	55.59	74	52	49.60
Two-Mile Beach (?) (a. 1851)	38	57	26.13	74	50	40.10
Leaming's Point (?) (a. 1851)	39	00	56.64	74	50	58.48
Town Bank (?) (a. 1851)	38	58	36.94	74	57	21.96
Cresse (?) (a. 1851)	39	03	00.05	74	49	28.91
Nummy's Island (?) (a. 1851)	39	01	39.50	74	47	09.31
Cyrus (?) (a. 1851)	39	04	28.55	74	44	01.20
Eldridge (?) (a. 1851)	39	06	03.41	74	47	17.07
Holmes (?) (1840)	39	07	32.71	74	45	53.73
Leaming's Beach North (?) (1840)	39	06	26.06	74	42	12.54
Townsend (?) (1840)	39	10	23.84	74	43	09.98
Ludlam's Beach (?) (1840)	39	08	41.50	74	41	29.69
Corson (?) (1840)	39	13	41.40	74	40	35.77
Mountain Creek (?) (1840)	39	11	42.80	74	38	51.74
Weakfish Creek (?) (1840)	39	13	28.80	74	37	38.73
Blackman (?) (1840)	39	15	04.74	74	39	13.93
Beasley's Point (?) (1840)	39	16	46.91	74	37	21.48

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
CAPE MAY COUNTY—Continued.	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Peck's Beach (?) (1840)	39	16	11.77	74	34	51.52
Cape Henlopen Light-house, Del. (a 1851)	38	46	38.35	75	04	43.24
Clarke's Spheroid. Difference			*+03.2*			*+19.6*
Beasley's Point (?) (1840)	39	16	50.07	74	37	41.01
Beasley's (2). (1884)	39	17	02.53	74	37	00.20
Blackman (?) (1840)	39	15	07.92	74	39	33.47
Corson (?) (1884)	39	12	01.01	74	39	21.35
Corson (?) (1840)	39	13	44.60	74	40	55.32
Stipson Island (?) (1842)	39	11	54.67	74	54	38.00
Ludlam's Landing (?) (1842)	39	10	41.75	74	51	09.74
McCrea. (1842)	39	09	52.62	74	50	45.96
Goshen. (1881)	39	07	39.64	74	53	30.63
Public (1884)	39	09	03.43	74	44	48.17
Tatham. (1884)	39	06	20.34	74	43	31.72
View. (1884)	39	10	39.38	74	43	11.40
Isle. (1884)	39	10	36.65	74	40	32.66
Marshall (1884)	39	12	13.47	74	41	47.00
Sea (1884)	39	08	59.50	74	42	15.64
Town Bank. Hotel cupola. (1881)	39	59	14.32	74	57	30.84
Hammock. (1881)	39	07	00.00	74	53	30.65
Young. (1884)	39	13	48.24	74	40	19.20
Cedar. (1884)	39	13	34.08	74	38	12.08
Heart. (1884)	39	15	34.23	74	38	35.80
Road (1884)	39	15	05.28	74	36	53.77
Eldridge (2). Cedar stub, Ephraim Eldridge's bay front. (1881)	39	06	06.63	74	47	36.46
Limerick chimney. Tallest on old dwelling, Tatham's Beach. (1881)	39	05	43.37	74	43	23.69
Peck's Beach (?) (1840)	39	16	14.93	74	35	11.10
Cape May Court-house spire	39	04	53.00	74	49	29.00
Tuckahoe. Spire. (V.)	39	17	32.4	74	45	17.6
CUMBERLAND COUNTY.						
Bessel's Spheroid—						
Barker (?) (1839)	39	26	16.76	75	21	45.94
PINE MOUNT (?) (1839)	39	25	00.57	75	19	56.46
Harris (?) (1839)	39	25	06.89	75	17	16.25
Hann (No. 2) (?) (1839)	39	25	24.01	75	15	07.01
Buck (?) (1839)	39	25	07.50	75	13	16.99
Greenwich (?) (1839)	39	23	24.39	75	20	21.71
Davis (?) (1839)	39	22	37.32	75	20	11.84
Heusted (No. 2) (?)	39	22	55.14	75	18	38.64
Wheaton (?) (1839)	39	23	26.60	75	19	05.89
Mount Pleasant. N. side Cohansey Creek, 3 miles below Bridgeton. (1839) (?)	39	23	21.96	75	15	02.76
Bush Hill (?) (1842)	39	23	56.56	75	15	23.71

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
CUMBERLAND COUNTY—Continued.	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Garrison (?) Hill E. side of Bridgeton and Fairton road. (1840)	39	23	33.66	75	13	02.91
Dunck's Beach (?) (1839)	39	20	32.91	75	21	50.90
Dayre (?) (1839)	39	21	44.55	75	19	53.57
Sheppard (?) (1839)	39	22	38.22	75	21	03.34
Cohansey Light-house. Old light-house. (1840)	39	20	18.39	75	21	17.48
Big Island. Buried cone. (1839)	39	19	45.61	75	18	14.08
West Point (?) (1840)	39	19	03.05	75	15	10.69
Ben Davis (?) (1839)	39	17	12.09	75	17	09.57
Eagle Island (?) (1840)	39	17	46.00	75	14	07.56
Nantuxent (?) (1840)	39	16	33.54	75	14	25.95
Flax Farm (?) (1840)	39	16	33.25	75	12	54.39
JOSCELYNE (?) (1840)	39	18	37.02	75	08	03.49
Turkey Point (?) (1840)	39	14	55.97	75	07	21.46
Fortesque (?) (1840)	39	14	09.39	75	09	59.99
Egg Island Point (?) (1841)	39	10	23.53	75	07	49.00
Egg Island Light-house. (1840.) Old light-house, now destroyed	39	10	30.89	75	08	01.74
Oranoken (?) (1840)	39	12	04.47	75	06	24.62
Egg Island Point (2) (?)	39	10	21.79	75	07	45.94
Dividing Creek. Buried cone, S. side of creek, ¾ mile below bridge. (1840)	39	15	16.96	75	05	04.11
Port Norris (?) (1839)	39	14	33.03	75	00	57.47
East Point (?) (1840)	39	11	28.35	75	00	58.06
Elder Point (?) (1842)	39	12	39.59	75	02	32.32
Bird Island (?) (1842)	39	11	44.34	75	01	09.96
Tomlin (?) (1842)	39	13	43.58	74	59	49.96
Wiggins (?) (1842)	39	14	33.23	74	59	47.70
Robinson (?) (1842)	39	11	23.73	74	59	22.90
West Creek (?) (1842)	39	10	27.02	74	54	44.79
Carlisle (?) (1842)	39	12	03.25	74	56	48.15
Bombay Hook Light-house, Del. (1840)	39	21	46.22	75	30	18.92
Mahon's River Light-house, Del. (1840)	39	10	16.40	75	23	43.43
Clarke's Spheroid. Difference			*+03.1*			*+19.4*
Barker (?) (1839)	39	26	19.96	75	22	05.40
PINE MOUNT (?) (1839)	39	25	03.79	75	20	15.94
John Dayre. Buried cone, 1½ miles N. E. of Bridgeton (?) (1840)	39	26	23.79	75	12	46.93
Hawkins (?) (1839)	39	25	35.42	75	20	40.87
Hann. Buried cone, S. side of Bridgeton and Bowentown road. (1839)	39	25	27.09	75	15	26.63
Buck (?) (1839)	39	25	10.71	75	13	36.54
Harris (?) (1839)	39	25	10.11	75	17	35.77
Wheaton (?) (1839)	39	23	29.83	75	19	25.40
Hann (2). (Same as Hann, nearly) (?)	39	25	27.22	75	15	26.55
Greenwich (?) (1839)	39	23	27.61	75	20	41.20
Bush (?) (1839)	39	23	59.79	75	15	43.25
Sheppard (?) (1839)	39	22	41.43	75	21	22.81

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
CUMBERLAND COUNTY—Continued.	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Davis (?) (1839)	39	22	40.55	75	20	31.34
Heusted (?)	39	22	58.37	75	18	58.15
Heusted (2) (?)	39	22	58.36	75	18	58.15
Mt. Pleasant (?)	39	23	25.17	75	15	22.30
Bridgeton spire. (1840)	39	25	46.48	75	13	57.71
Laurel (?)	39	26	21.44	75	13	43.04
Woodruff. N. side of Bridgeton and Millville road, 1 mile W. of Millville township line (?) (1840)	39	24	49.75	75	08	47.25
Cedarville spire. (1840)	39	20	01.99	75	12	07.72
Cedarville. Summit, N. E. of new brick church (?) (1840)	39	20	38.48	75	11	50.65
Fairton. Buried cone on Theoph. Harris' land. (1839) (?)	39	22	33.37	75	13	12.26
Ogden (?) (1839)	39	22	06.57	75	15	28.23
Jacob's Creek (2). 1½ miles N. of Cohansey Light-house. Cedar stub. (1875)	39	21	40.07	75	23	38.25
Jacob's Creek (?)	39	21	37.25	75	23	36.45
Dunck's Beach. On sand ridge, ½ mile N. of Cohansey Light-house	39	20	36.17	75	22	10.38
Dunck's Beach (2)	39	20	36.34	75	22	10.63
Dayre (?)	39	21	47.78	75	20	13.07
Cohansey Light-house. (1840.) Disused.	39	20	21.64	75	21	36.98
Big Island. Buried cone. (1839) (?)	39	19	48.86	75	18	33.60
Sea Breeze. Warner House flag-staff. (1882)	39	19	26.71	75	19	14.83
Garrison (?) (1840). (Same as previous)	39	23	36.88	75	13	22.47
West Point (?) (1840). (Same as previous)	39	19	06.31	75	15	30.23
Ben Davis (?) (1839). (Same as previous)	39	17	15.36	75	17	29.10
Ben Davis (2) (?)	39	17	18.36	75	17	26.98
Eagle Island (?) (1840). (Same as previous)	39	17	49.26	75	14	27.10
Nantuxent (?) (1840). (Same as previous)	39	16	36.81	75	14	45.49
Flax Farm (?) (1840). (Same as previous)	39	16	36.52	75	13	13.95
JOSCELYNE (?) (1840). (Same as previous)	39	18	40.25	75	08	23.09
Ben. Drain-pipe sunk in sand at extreme high-water mark, Ben Davis Point. (1882)	39	17	18.47	75	17	26.97
Nan. Drain-pipe and cement, below mouth of Nanticoke Creek. (1882)	39	16	40.53	75	14	46.80
Dyer's Cove. Drain-pipe planted in marsh. (1882)	39	16	06.54	75	13	42.42
Turkey Point (?) (1840). (Same as previous)	39	14	59.23	75	07	41.06
Bradford's Point. Terra-cotta pipe, ¼ mile below Padget's Creek. (1881)	39	15	56.35	75	11	53.95
Fortesque. Pavilion flag-staff. (1882)	39	14	12.23	75	10	19.14
Fortesque. Big flag-staff. (1882)	39	14	15.38	75	10	14.22
Fortesque (?) (1840)	39	14	12.65	75	10	19.60
Fortesque (2). Terra-cotta pipe on sand hill, 332 feet S. E. of pavilion. (1881)	39	14	07.19	75	10	16.10
Dividing Creek (?) (1840). (Same as previous)	39	15	20.22	75	05	23.72
Oranoken (?) (1840). (Same as previous)	39	12	07.74	75	06	44 21

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
CUMBERLAND COUNTY—Continued.	Deg.	Min.	Sec.	Deg.	Min.	Sec.
False Point (?) (1840)	39	12	00.55	75	10	17.92
False Egg Point, at high-water mark. (1882)	39	12	01.23	75	10	11.92
Egg Island Light-house. (1882)	39	10	43.82	75	08	13.22
Port Norris. Buried cone, land of Harriet Ogden. (1839)	39	14	36.29	75	01	17.09
Elder Point (?) (1842)	39	12	42.86	75	02	51.93
Bird Island. (1842)	39	11	47.61	75	01	29.58
Wiggins. (1842.) (Same as previous)	39	14	36.49	75	00	07.31
Tomlin. (1842.) (Same as previous)	39	13	46.84	75	00	09.58
East Point. On sand hill, 1½ miles E. of Maurice river (?)	39	11	31.62	75	01	17.70
Tripod (?)	39	12	36.04	75	02	43.10
Maurice River West. Buried cone, W. side of river mouth. (1840) (?)	39	12	43.20	75	02	53.16
Robinson (?) (1842)	39	11	27.01	74	59	42.54
Egg Island (2)	39	10	25 07	75	08	05.52
Maurice River Light-house. (1877)	39	11	45.23	75	01	39.53
Carlisle. Buried cone (1842) on farm of Wm. Carlisle, of Leesburg	39	12	06.52	74	57	07.80
West Creek. (1842)	39	10	30.30	74	55	04.47
West Creek. (2). (1881)	39	10	37.79	74	54	58.35
Elmer (?)	39	22	13.17	75	09	09.39
Ship John Light-house. (1882)	39	18	19.10	75	22	37.08
Bombay Hook Light-house. (1882)	39	21	49.49	75	30	38.34
Vineland Church. (B.)	39	29	10.17	75	01	16.12
Roman Catholic Seminary. (B.)	39	29	43.26	75	01	37.26
Vineland. Church spire. (V.)	39	29	10.2	75	01	16.1
Bridgeton. Charles R. Elmer's house cupola. (V.)	39	25	37.2	75	12	50.5
Bridgeton. Baptist Church spire. (V.)	39	25	43 2	75	13	58.1
Deerfield. (B.)	39	32	32.23	75	13	24.37
Dividing Creek. (V.)	39	18	33.7	75	05	15.1
Fairton. (V.)	39	22	13.9	75	09	09.6
Woodruff. (V.)	39	24	49.1	75	08	46.9
Millville. Stand-pipe. (V.)	39	24	15.1	75	02	52.7
Kellogg (V.)	39	26	00.5	74	59	09.8
Pine Mount. (V.)	39	25	06.4	75	20	11.5
Dutch Neck. (V.)	39	23	24.1	75	15	13.0
Mulford's Landing. (V.)	39	22	21.1	75	19	26 0
Muskee Hill. (V.)	39	18	42.2	74	57	08 2
ESSEX COUNTY.						
Bessel's Spheroid—						
Crane (2). Summit First Mountain, N. of Montclair (?) (a. 1851)	40	50	05.42	74	12	48.86
Wallace. In Newark city (?) (a. 1851)	40	44	30.41	74	10	56.09
Newark Neck (?) (a. 1851)	40	42	44.97	74	08	00.00

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
ESSEX COUNTY—Continued.	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Fairfield. Reformed Church spire. (B.)..	40	53	01.94	74	16	38.13
Caldwell. Church spire. (B.)...............	40	50	18.38	74	16	14.02
Caldwell. Iron bar, projecting 3 inches, 1 mile E. of village, near top of hill. (B.)..	40	50	21.69	74	15	04.77
Newark. First Presbyterian Church spire. (a. 1859)...	40	44	01.18	74	10	02.26
Newark. Methodist Church spire. Broad street. (a. 1859).............................	40	44	03.58	74	09	52.60
Newark Bay Light or Passaic Light (a.1859)	40	41	43.69	74	07	19.23
Newark Bay Beacon. (a. 1859)...............	40	42	05.60	74	07	07.97
Clarke's Spheroid. Difference..................			*+02.6*			*+19.9*
Newark. Episcopal Church spire...........	40	44	25.42	74	10	10.35
Fairfield. Church spire. (V.)...............	40	53	04.4	74	16	58.0
Caldwell. Flag. (V.)...........................	40	50	44.1	74	15	24.7
GLOUCESTER COUNTY.						
Bessel's Spheroid—						
Big Timber Creek (?) (a. 1851)................	39	52	42.68	75	07	45.54
Red Bank flag-staff. (a. 1851).................	39	52	17.35	75	11	01.59
Woodbury Creek (?) (a. 1851)...	39	51	50.06	75	11	33.29
Mathew (?) (a. 1851)................................	39	51	16.54	75	12	23 33
Billingsport (?) (a. 1851)........................	39	51	00.24	75	14	15.88
Isaac (?) (a. 1851)..................................	39	50	44.84	75	15	23.37
Chew. Hill, 1 mile N. of Mantua (?) (a. 1851)..	39	48	13.89	75	09	42.28
Oldman Creek (?) (a. 1851).....................	39	47	01.84	75	25	33.11
Opposite Marcus Hook (?) (a. 1851).........	39	47	39.07	75	24	02.17
Tonkin's Island. West (?) (a. 1851).........	39	48	48.96	75	22	31.28
Tonkin's Island. East (?) (a. 1851).........	39	49	11.40	75	21	40.94
Man Island (?) (a. 1851).........................	39	50	19.67	75	19	08 59
Thompson Point (?) (a. 1851)..................	39	50	31.83	75	18	04.50
Crab Creek (?) (a. 1851)..........................	39	50	36.40	75	17	20.33
Eagle Point (?) (a. 1851).........................	39	52	39.28	75	09	41.21
Opposite Chester (?) (a. 1851)..................	39	49	40.27	75	20	20.24
Robbins (2). (1843)..................................	39	44	31.29	75	19	42.75
Scull (1) (1843).......................................	39	43	30.01	75	20	22.73
LIPPENCOTT. On hill, 2 miles S. of Swedesboro. (1843)..	39	43	17.44	75	18	30.36
Swedesboro spire. Episcopal Church. (1843)	39	44	58.94	75	18	07.32
Caffery. ½ mile S. E. from Clarksboro. (1843)...	39	47	28.44	75	12	59.73
West. 2 miles from Mullica Hill, summit of road to Mantua. (1843)..................	39	45	36.73	75	12	00.61
Fort Mifflin flag-staff, Pa. (a. 1851).........	39	52	28.57	75	12	25 88
Chester Roman Catholic Church, Pa. (a. 1851)...	39	51	02.20	75	21	19.52
Clarke's Spheroid. Difference..................			*+03.1*			*+19.4*

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
GLOUCESTER COUNTY—Continued.	Deg.	Min.	Sec.	Deg.	Min.	Sec.
LIPPENCOTT. (See above.) (1843)	39	43	20.55	75	18	49.82
Forest Grove. (B.)	39	31	45.77	74	59	21.81
Williamstown Ch. (B.)	39	40	54.60	74	59	23.20
Clayton Ch. (B.)	39	39	26.29	75	05	29.73
NEWFIELD. 1¼ miles S. E. of village. (B.)	39	32	13.85	75	00	16.14
WILLIAMSTOWN. In glass works yard. (B.)	39	40	56.31	74	59	28.5
TAYLOR'S MOUNT. 1 mile S. W. of Richwood. (B.)	39	42	57.42	75	10	37.79
Glassboro Church spire. (B.)	39	42	00.79	75	06	47.11
Monroe. S. of Monroeville. (B.)	39	37	22.71	75	07	28.12
Clarksboro Church spire. (B.)	39	47	57.49	75	13	29.09
Swedesboro Church spire. (B.)	39	45	02.04	75	18	26.76
Chester, Pa. Military Academy cupola. (B.)	39	51	41.95	75	21	20.38
Stringtown (Lincoln). (V.)	39	40	13.3	75	14	18.8
Glassboro. White spire. (V.)	39	42	00.7	75	06	46.7
Clayton. Spire. (V.)	39	39	26.3	75	05	29.4
Iona. Tall pine in swamp, S. W. of R. R. station. (V.)	39	36	10.2	75	04	38.2
Williamstown. Spire. (V.)	39	40	54.6	74	59	23.2
Piny Hollow. (V.)	39	35	09.9	74	55	39.7
Forest Grove. Church spire. (V.)	39	31	45.8	74	59	21.8
Newfield. On hill, 1¼ miles S. E. of village. (V.)	39	32	13.8	75	00	16.1
HUDSON COUNTY.						
Bessel's Spheroid—						
Schuyler. On ridge, E. of Belleville (?) (a. 1851)	40	46	46.28	74	08	10.17
Bergen Neck (?) On ridge in West Hoboken (?) (1818)	40	45	49.40	74	02	16.62
Stevens. In front of Stevens residence, Hoboken. (a. 1851)	40	44	38.49	74	01	06.54
Bergen spire. Old Dutch Reformed Church. (a. 1851)	40	43	39.51	74	03	43.22
Caven Point (?) (a. 1851)	40	41	31.36	74	03	59.07
Palmerpaw (?) (a. 1851)	40	40	38.24	74	05	39.32
Constable's Point (?) (a. 1851)	49	39	23.52	74	05	25.61
Vanhorne (?) (2) (a. 1851)	40	39	05.63	74	08	06.80
Shooter's Island (?) (a. 1851)	40	38	34.24	74	09	20.04
Rowan (?) (a. 1851)	40	38	51.54	74	07	13.72
Bedloe's Island (flag-staff). New York Bay. (a. 1851)	40	41	17.48	74	02	20.85
Gibbet Island (tree). Now Ellis Island, New York Bay. (a. 1851)	40	41	55.72	74	02	05.49
Jersey City (flag-staff). (a. 1851)	40	42	52.43	74	01	57.20
Passionate Fathers' Monastery. West Hoboken. (B.)	40	45	54.38	74	01	52.28

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
HUDSON COUNTY—Continued.	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Brooklyn Bridge. New York pier. (B.)	40	42	23.57	73	59	35.51
Bergen Point spire. (a. 1859)	40	38	49.58	74	07	19.24
Centerville. Church spire. (a. 1859)	40	40	03.23	74	06	33.26
Kill's Light. Bergen Point. (a. 1859)	40	38	32.23	74	08	35.84
Robin's Reef Light. New York Bay. (a. 1859)	40	39	23.85	74	03	36.78
New York City Hall, N. Y. (a. 1851)	40	42	43.16	74	00	03.09
New York. Trinity Church spire. (a. 1851)	40	42	25.71	74	00	24.29
Brooklyn. Trinity Church spire	40	40	56.33	73	57	43.06
Clarke's Spheroid. Difference			*+02.6*			*+19.9*
Highwood (2). Brick pillar, marble cap in miniature redoubt, near residence of Mrs. James G. King (1867), 2 miles N. of Hoboken	40	46	12.70	74	01	02.06
Bergen Neck (?) (1818)	40	45	52.06	74	02	36.50
Stevens. (a. 1851)	40	44	41.14	74	01	26.44
Bergen Dutch Reformed Church. (Same as above.) (1885)	40	43	37.14	74	04	04.35
Jersey City. Spire. (a. 1851)	40	42	53.18	74	02	16.75
Oil Co.'s chimney. N. side of Kill von Kull. (1885)	40	39	18.82	74	06	33.44
Shooter's Island. Chimney. (1885)	40	38	32.58	74	09	39.70
HUNTERDON COUNTY.						
Bessel's Spheroid—						
Fox Hill. Stone monument on summit, 2 miles N. E. of Califon. (B.)	40	43	56.31	74	47	59.45
Bethlehem. Masonry monument over Lehigh Valley R. R. tunnel. (B.)	40	38	49.95	75	01	18.99
Gravel Hill. Cross cut on rock on summit, 3 miles N. W. of Milford. (B.)	40	35	18.87	75	08	06.80
PICKLES. Stone monument, most southerly summit of mountain. (B.)	40	35	38.26	74	49	06.57
Readington. Reformed Church spire. (B.)	40	34	02.46	74	43	49.59
Cherryville. Stone monument, ¼ mile W. of village. (B.)	40	33	42.45	74	54	11.41
Croton. Stone monument on summit, 2 miles S. E. of village. (B.)	40	29	01.42	74	54	25.95
Three Bridges. Church spire. (B.)	40	31	20.53	74	47	29.89
Flemington. Methodist Church spire. (B.)	40	30	17.53	74	51	10.62
Pleasant Corner. Church spire. (B.)	40	26	25.98	74	51	04.55
Sand Ridge. Baptist Church spire. (B.)	40	25	20.45	74	56	54.99
Sourland. White-oak stump, ½ mile W. of Amwell village. (B.)	40	25	48.96	74	45	19.50
GOAT HILL. Stone monument on summit, 1½ miles S. of Lambertville. (B.)	40	20	42.05	74	55	57.47
HAYCOCK, PA. Summit, 2 miles S. of Bucksville. (B.)	40	29	16.09	75	12	50.97

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
HUNTERDON COUNTY—Continued.	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Clarke's Spheroid. Difference			+02.7			+19.6
Pottersville. (V.)	40	42	24.8	74	44	06.1
Readington. Church spire. (V.)	40	34	05.2	74	44	09.2
Cherryville. Spire. (V.)	40	33	44.7	74	54	15.5
Quakertown. Spire. (V.)	40	33	52.9	74	56	31.5
Cushetunk. (V.)	40	37	24.8	74	48	26.9
Mechanicsville. Church spire. (V.)	40	37	11.2	74	45	00.4
Cornhill. (V.)	40	22	23.8	74	54	42.7
Rosemont. Spire. (V.)	40	25	49.4	74	59	26.4
MERCER COUNTY.						
Bessel's Spheroid—						
MOUNT ROSE. Top of mountain, ¾ mile E. of village. (1840)	40	22	00.56	74	43	06.14
Poplar Ridge (?) (1840)	40	22	14.30	74	42	10.75
Mount Canoe. Buried cone on hill, 1¾ miles N. E. from Titusville (?) (1840)	40	19	37.76	74	51	19.98
Cold Soil (2) (?) (1840)	40	20	37.84	74	42	13.90
Pennington Seminary (cupola). (1840)	40	19	35.36	74	47	18.30
Princeton Seminary (cupola). (1840)	40	20	40.00	74	39	34.26
Princeton College (cupola). (1840)	40	20	52.06	74	39	15.26
Mapleton (2) (?) (1840)	40	21	08.62	74	36	23.83
Lawrenceville. Buried cone. Hill N. W. of village (1840)	40	18	05.01	74	43	48.71
Lawrenceville (spire). (1840)	40	17	51.00	74	43	25.25
Hazel's Farm (2). Middle of New Brunswick and Trenton turnpike, 30 yards N. of Chas. Updeck's house. (1840)	40	18	02.77	74	40	08.69
Trenton. First Presb. Church spire. (1840)	40	13	10.23	74	45	29.54
White Horse (?) (1840)	40	11	10.70	74	42	07.51
Clarke's Spheroid. Difference			+02.8			+19.6
Princeton water-tower. (V.)	40	20	23.5	74	40	03.5
Princeton College cupola (V.)	40	20	55.0	74	39	35.1
Lawrenceville stand-pipe. (V.)	40	17	31.9	74	44	10.9
Ewing Church spire. (V.)	40	16	14.4	74	48	02.5
East Trenton. Rubber Works ch'y. (V)	40	14	23.0	74	43	39.0
Trenton. State and Clinton St. spire. (V.)	40	13	16.8	74	45	21.3
Trenton. State House dome. (V.)	40	13	13.8	74	46	13.1
Trenton. State Street Methodist Church spire. (V.)	40	13	13.5	74	45	36.7
Trenton. Roman Catholic Church, Broad and Centre streets. (V.)	40	12	51.5	74	45	40.6
Trenton. Bapt. Church, Centre and Bridge streets. (V.)	40	12	41.4	74	45	36.4
Hamilton Square Baptist Church. (V.)	40	13	46.1	74	39	37.3
Dutch Neck spire. (V.)	40	16	57.5	74	36	50.3
Windsor spire. (V.)	40	14	34.5	74	34	57.7

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE		
MIDDLESEX COUNTY.	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Bessel's Spheroid—						
Williams (2) (?) (a. 1851)	40	34	51.18	74	12	31.94
Woodbridge (?) (a. 1851)	40	33	22.51	74	14	20.83
Woodbridge. Spire of Presbyterian Church. (a. 1859)	40	33	39.82	74	16	05.95
Zellis (2). On hill, ½ mile S. of Woodbridge (?) (a. 1851)	40	32	43.02	74	16	17.64
Shotwell (?) (a. 1851)	40	32	45.43	74	15	01.06
BLOOMFIELD. Summit of Bloomfield's Hill, 2 miles E. of Metuchen. (a. 1851)	40	32	04.01	74	19	08.84
Perth Amboy. Episcopal Church spire. (a. 1859)	40	30	10.64	74	15	36.15
South Amboy. (a. 1851)	40	28	44.61	74	16	59.98
Morgan (?) (a. 1851)	40	28	01.06	74	15	39.33
Chestnaquack (?) (a. 1851)	40	27	37.43	74	14	43.39
Sandhills. Summit on New Brunswick and Trenton turnpike. (a. 1851)	40	24	27.30	74	32	19.08
Cranbury. Steeple First Presb. Church. (a. 1851)	40	18	23.68	74	30	48.32
New Brunswick. Rutgers Col. cupola. (B.)	40	29	52.73	74	26	28.12
Woodbridge Landing (?) (a. 1859)	40	32	43.23	74	14	59.71
Fire Brick Works. A. Hall & Son's ch'y, Perth Amboy. (a. 1859)	40	30	51.06	74	15	16.06
Perth Amboy. Presb. Church. (a. 1859)	40	30	18.09	74	15	37.80
South Amboy Depot. Pennsylvania R. R. (a. 1859)	40	29	26.32	74	16	15.58
Seward (?) (a. 1859)	40	28	52.90	74	16	13.05
Morgan (2) (?) (a. 1859)	40	28	08.05	74	15	36.15
Morgan (3) (?) (a. 1859)	40	28	05.18	74	15	33.80
Chestnaquack Point (2) (?) (a. 1859)	40	27	36.88	74	14	42.36
Clarke's Spheroid. Difference			*+02.7*			*+20.0*
Bayard. Bank of Arthur Kill, N. of Island View landing. Buried bottle. (1885)	40	35	01.66	74	12	43.94
Sawyer. Tuft's Point, N. bank Arthur Kill. Buried bottle. (1885)	40	33	38 86	74	13	26 27
Woodbridge. Spire of Presbyterian Church. (1885, same as a. 1851)	40	33	42.50	74	16	25.94
Hawk. 18 yards E. of Clark's Creek, (1885)	40	33	41.77	74	14	26.40
Sewaren. Cedar stub. 160 yards N. of Sewaren Hotel. (1885)	40	32	47.50	74	15	18.54
Boynton's Tile Works chimney. Near Woodbridge Landing. (1885)	40	32	26.58	74	15	21.56
Menlo Park. Tall iron stack. (V.)	40	33	49.0	74	20	22.5
Van Keuren's house. 1 mile S. W. of Newtown. (V.)	40	32	16.4	74	28	06.2
Metuchen. Presbyterian Church spire. (V.)	40	32	25.7	74	21	34.5
Rutgers College cupola, New Brunswick. (V.)	40	29	55.4	74	26	47.7

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
MIDDLESEX COUNTY—Continued.	Deg.	Min.	Sec.	Deg.	Min.	Sec.
St. James' spire. New Brunswick. (V.)...	40	29	38.0	74	26	53.9
Stelton. Church spire. (V.)...	40	31	01.5	74	24	26.0
Kreischer's chimney, Staten Island. (V.)..	40	31	57.1	74	14	28.8
Tottenville. Cupola, Staten Island. (V.)..	40	30	30.9	74	14	37.9
State Reform School tower. (V.)...	40	20	35.6	74	23	55.6
Dayton. Church spire. (V.)...	40	22	32.8	74	30	43.7
Cranbury. First Presb. Church spire. (V.)...	40	18	26.4	74	31	08.3
Cranbury. Second Presb. Church spire. (V.)...	40	18	50.4	74	30	51.6
MONMOUTH COUNTY.						
Bessel's Spheroid—						
Matavan Point (?) (a. 1851)...	40	26	50.28	74	12	19.53
Conasconck Point (?) (a. 1851)...	40	27	30.90	74	10	24.21
Point Comfort (?) (a. 1851)...	40	27	20.79	74	07	45.05
Compton (?) (a. 1851)...	40	26	19.74	74	05	09.94
Sandy Hook (?) (a. 1851)...	40	27	42.18	74	00	04.80
Sandy Hook Light-house. (a. 1859)...	40	27	39.49	73	59	48.56
Pigeon Hill (?) (a. 1851)...	40	24	24.49	74	04	23.33
Mount Mitchell. N. edge of Highlands. (a. 1851)...	40	24	27.77	74	00	06.30
BEACON HILL. Hill 1 mile S. E. of Morganville. (1839)...	40	22	23.74	74	13	22.06
Beers. Hill W. side of Keyport and Holmdel road. (1843)...	40	23	30.96	74	11	06.29
Navesink (?) (a. 1851)...	40	23	45.06	73	58	49.77
Navesink Light-house. (a. 1851)...	40	23	42.43	73	58	48.62
Ocean House (flag-staff). (a. 1851)...	40	22	51.74	73	58	13.90
Burdge. Hill N. bank of Navesink river. (1843)...	40	22	59.43	74	01	25.80
Navesink (2) (?) (a. 1851)...	40	23	15.34	73	58	53.50
Garriell. Hill 1 mile S. E. of Red Bank. (a. 1851)...	40	20	31.69	74	02	45.79
Conover (?) (a. 1843)...	40	20	38.28	74	01	07.42
Beach (1) (?) (a. 1851)...	40	20	39.12	73	58	01.68
Beach (2) (?) (a. 1851)...	40	20	11.87	73	58	02.84
Polhemus. Hill 2½ miles N. E. of Colt's Neck. (1843)...	40	19	00.00	74	08	36.62
Shrewsbury spire. (a. 1851)...	40	19	22.20	74	03	21.63
Liberty pole. Long Branch village. (a. 1840)...	40	17	55.55	73	59	52.30
DISBORO. Hill 1½ miles N. W. of Perrineville. (1840)...	40	14	45.43	74	27	06.10
Baird. N. end Pine Hill, 1½ miles N. E. of Perrineville. (1840)...	40	14	07.05	74	24	31.26
Debow. Hill 1 mile S. E. of Clarksburgh (?) (1840)...	40	10	55.37	74	25	16.89
Freehold. Spire, old Court House (?) (1840)	40	15	34.38	74	16	08.50

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
MONMOUTH COUNTY—Continued.	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Grandon. Hill 2 miles E. of Freehold. (1840)	40	15	44.62	74	13	35.86
Throckmorton. Hill 2½ miles S. of Colt's Neck. (1836)	40	15	01.08	74	10	28.68
Lippencott. Hill 1½ miles N. of Shark River R. R. station (?) (1836)	40	15	17.63	74	07	18.27
West. Hill ½ mile N. of Elberon R. R. station (?) (a. 1851)	40	16	16.24	73	59	34.71
Red Bog. On hill, 2½ miles W. of Asbury Park. (a. 1851)	40	14	03.28	74	02	54.16
Newell. On hill, 2 miles S. E. of Turkey. (a. 1851)	40	11	41.15	74	14	05.77
Highland of Squan (?) (a. 1851)	40	06	07.68	74	04	17.70
Sandy Hook Signal (?) (a. 1859)	40	28	17.05	74	00	03.21
Conasconck Point (2) (?) (a. 1859)	40	27	30.60	74	10	24.74
Wilson's Beacon. Back of Point Comfort. (a. 1859)	40	26	35.80	74	07	51.32
Light-house flag. Near Point Comfort. (a. 1859)	40	26	50.75	74	06	56.81
Matavan (?) (a. 1859)	40	26	48.87	74	12	18.90
Keyport spire. (a. 1859)	40	26	12.41	74	11	47.24
Conover's Beacon. (a. 1859)	40	25	14.21	74	03	01.39
Hilton (?) (a. 1859)	40	25	17.19	74	03	09.44
Carhart (?) (a. 1859)	40	25	01.13	74	02	11.66
Chapel Hill. Back light. (a. 1859)	40	23	51.00	74	03	12.76
Chapel Hill. Light-house pole. (a. 1859)	40	23	51.68	74	03	12.67
Wilson (?) (a. 1859)	40	26	18.87	74	05	08.92
Clarke's Spheroid. Difference			*+02.8*			*+19.9*
BEACON HILL. (See above)	40	22	26.55	74	13	41.91
Throckmorton. (See above)	40	15	03.90	74	10	48.57
Garriell. (See above)	40	20	34.44	74	03	05.72
West. (See above)	40	16	18.98	73	59	54.71
Red Bog. (See above)	40	14	06.10	74	03	13.71
Red Bog (2) (?)	40	14	05.81	74	03	13.71
Freehold. Court House spire. (V.)	40	15	37.3	74	16	29.6
Freehold. Reformed Church spire. (V.)	40	15	28.0	74	16	42.4
Key East Hotel. Flag-staff. (V.)	40	11	29.6	74	00	37.8
Colorado House. Ocean Beach. (V.)	40	10	23.8	74	00	57.5
Beach House, Sea Girt. N. flag-staff. (V.)	40	07	34.8	74	01	49.9
Disbrow Hill. (V.)	40	14	48.0	74	27	26.1
Allentown. Presb. Church spire. (V.)	40	10	27.1	74	35	14.6
MORRIS COUNTY.						
Bessel's Spheroid—						
East and West Jersey Line. 1½ miles N. of Budd's Lake. (B.)	40	53	46.46	74	44	34.43
Green Pond. Blazed pine on summit, 1 mile N. of Denmark. (B.)	40	58	31.04	74	31	41.93

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
MORRIS COUNTY—Continued.	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Sheep Hill. Cross cut on large rock on summit, 1 mile N. of Boonton. (B.)	40	55	06.58	74	24	04.35
Boonton, Presb. Church spire. (B.)	40	54	20.92	74	24	17.68
Parsippany. Presb. Church spire. (B.)	40	51	50.17	74	24	04.17
Schooley's Mountain. Cross on center one of three stones on summit, 1¼ miles S. W. of Drakestown. (B.)	40	49	44.93	74	47	13.45
Watnong. Bar of iron, projecting 6 inches, on summit, 1½ miles N. W. of Morris Plains. (B.)	40	50	52.88	74	29	30.23
Morristown. Presb. Church spire. (B.)	40	47	47.83	74	28	30 19
MT. OLIVE. Stone monument on summit, 1½ miles E. of Budd's Lake. (B.)	40	51	59.88	74	42	32.80
BALD HILL. Stone monument, 1 mile S. E. of Brook Valley. (B.)	40	57	37.21	74	20	43 91
Clarke's Spheroid. Difference			*+02.6*			*+19.7*
Seward's Hill. Chester cross-roads. (V.)	40	47	12.8	74	40	35.2
Parsippany. Church spire. (V.)	40	51	52.7	74	24	24.2
OCEAN COUNTY.						
Bessel's Spheroid—						
Christopher. On a hill 1¾ miles S. E. of Lakewood, now a cemetery (?) (a. 1851)	40	04	10.42	74	11	36.75
Green Island (?) (a. 1851)	40	00	32.22	74	06	06 49
Fleming (?) (a. 1851)	40	00	12.97	74	03	11.79
Page (?) (a. 1851)	39	59	06.18	74	06	48.18
Stout (?) (a. 1851)	39	57	34 71	74	04	15.43
Goose Creek (?) (a. 1851)	39	57	04.97	74	06	20.38
Cranberry (?) (a. 1851)	39	56	37.21	74	03	58 55
Good Luck Point (?) (a. 1851)	39	55	18.58	74	06	47.10
Philipp (?) (a. 1851)	39	53	50.37	74	04	25.90
Cedar Creek (?) (a. 1851)	39	51	44.44	74	07	52 94
Forked River (?) (a. 1851)	39	49	19.83	74	09	08.41
Island Beach (?) (a. 1851)	39	49	02.52	74	05	08.73
Barnegat Inlet (?) (a. 1851)	39	45	55.47	74	05	55.43
Barnegat Light-house (a. 1851), old position; for new light-house, see below	39	45	57.21	74	06	02.20
Double Creek (?) (a. 1851)	39	44	24.84	74	10	20.39
Hickory Island (?) (a. 1851)	39	41	11.94	74	12	43.12
Great Swamp (?) (a. 1851)	39	40	39.53	74	08	39.32
Dinner Point (?) (a. 1851)	39	37	57.40	74	14	54.94
Hickey (?) (a. 1851)	39	37	34.20	74	11	03.36
Cramer (?) (a. 1851)	39	35	09.24	74	12	52.76
Long Beach (?) (a. 1851)	39	33	15.89	74	14	21.23
Clarke's Spheroid. Difference			*+03.0*			*+20.0*
Whitings Hotel flag-staff. (1873)	39	57	13.04	74	22	46.62

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
OCEAN COUNTY—Continued.	Deg.	Min.	Sec.	Deg.	Min.	Sec.
BALCONY. Buried jug at summit, 2 miles S. W. of Whitings. (1871)	39	55	27.09	74	23	40.94
RIDGEWAY. Summit, N. side of Cedar Bridge road, 5½ miles N. W. from Barnegat. (1872)	39	46	34.43	74	19	33.26
BARNEGAT LIGHT-HOUSE. Present light-house. (1873)	39	45	51 61	74	06	23.78
Barnegat. Methodist Church spire. (1873)	39	45	09.81	74	13	20.04
Gowdy's house. Cupola of Mr. J. G. Gowdy's residence, 1 mile E. of Toms River. (1873)	39	57	11.73	74	10	34.90
Sea Side Park. Flag-staff at post-office	39	55	15.5	74	04	44.0
Whitings. Hotel flag-staff. (V.)	39	57	13.1	74	22	46.5
Buckingham, ¼ mile N. of Philadelphia and Long Branch R. R., and just W. of Ocean County line. (V.)	39	55	57.9	74	28	30.8
PASSAIC COUNTY.						
Bessel's Spheroid—						
Van Riper. Summit, S. edge of Paterson (?)	40	53	34.04	74	08	04.34
Weasel. Copper bolt in ledge First Mountain, N. of Great Notch	40	52	34.18	74	10	52.41
Aquackanonk. Summit of hill, Passaic City (?)	40	51	01.13	74	07	25.80
Beach Mountain. Summit, near State line, E. of Greenwood Lake. (B.)	41	09	57.56	74	17	20.29
Dunker Pond. Blazed oak on summit, ¼ mile S. W. of pond. (B.)	41	04	55.90	74	28	37.23
BEAR FORT. Copper bolt in ledge on summit, 1½ miles N. W. of West Milford. (B.)	41	08	23.55	74	23	11.70
Macopin. Blazed chestnut on summit, ¼ mile E. of pond outlet. (B.)	41	02	53.61	74	23	43.79
HIGH MOUNTAIN. Copper bolt in ledge on summit, 4 miles N. W. of Paterson. (B.)	40	58	11.52	74	11	35.58
Powder Mills. Machine shop chimney. (B.)	40	55	27.51	74	16	13.59
Greenwood Lake, N. Y. Bearfort Mountain, N. of State line. (B.)	41	11	38.07	74	20	02.88
Clarke's Spheroid. Difference			*+02 6*			*+19.8*
WEASEL. (Same as Weasel above)	40	52	36.81	74	11	12.21
Wayne. Powder Mills chimney. (V.)	40	55	30.1	74	16	33.5
SALEM COUNTY.						
Bessel's Spheroid—						
Oldman's Point (?) (1843)	39	45	37.24	75	27	21.92
Penn's Grove (?) (1843)	39	43	59.74	75	28	19.10
Church Landing Point (?) (1843)	39	39	36.75	75	31	00.87

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
SALEM COUNTY—Continued.	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Allen. Buried cone, on hill 1½ miles S. W. of Auburn. (1843)	39	41	14.14	75	22	28.26
Scull (2). Buried cone, 2 miles N. from Sharpstown (?)	39	40	56.57	75	20	32.89
Ellet. Buried cone, 2½ miles from Sharpstown, on land of Widow Ellet (1843)	39	38	19.55	75	23	37.05
Reeves (?) (1843)	39	39	03.38	75	22	46.20
Acton. Buried cone, 2 miles E. of Sharpstown, on land of Widow Acton (?) (1843)	39	38	08.61	75	22	45.32
Big Mannington Hill. Buried cone 3 miles S. W. of Woodstown (1843)	39	36	54.09	75	21	21.79
Kinsey (?) (1843)	39	38	03.11	75	33	02.74
Finn's Point. Bank of Delaware (?) (1841)	39	35	58.11	75	32	45.92
Penn's Neck (?) (1843)	39	35	38.05	75	32	16.88
Fort Delaware, Del. (1839)	39	35	18.79	75	33	49.20
Salem spire, Episcopal Church. (1841)	39	34	25.42	75	27	37.98
Elsinborough Point. In old Swedish fort. (1841) (?)	39	32	21.74	75	31	44.41
Alloway's Point. Buried cone, 147 yards N. of mouth of Alloway's Creek (?) (1840)	39	30	04.77	75	31	30.83
BURDEN. 2½ miles S. E. from Quinton, and 300 yards W. of the cross-roads (?) (1840)	39	31	45.74	75	22	33.40
Stony Point (?) (1840)	39	27	29.89	75	30	49.85
Round Island (?) (1840). (See below)	39	25	18.79	75	27	13.74
Arnold (?) (1840)	39	23	14.78	75	25	40.49
Wilmington Light-house. (1841)	39	43	15.25	75	30	55.69
Wilmington Town Hall, Del. (1841)	39	44	26.56	75	32	42.43
Delaware City. Presbyterian Church spire, Del. (1841)	39	34	38.14	75	35	17.59
New Castle. Episcopal Church spire, Del. (1841)	39	39	35.71	75	33	27.34
Clarke's Spheroid. Difference			+03.2			+19.4
Finn's Point (2). Bank of Delaware (1875)	39	36	00.15	75	33	02.57
Finn's Point. Bank of Delaware (?) (1841)	39	36	01.32	75	33	05.22
Salem Presbyterian Church spire	39	34	24.10	75	27	59.28
Salem Episcopal Church spire. (See above)	39	34	28.58	75	27	57.30
Elsinborough. (See Elsinborough above) (1841)	39	32	24.91	75	32	03.76
Elsinborough (2) (1875). Pine stub, near old Elsinborough (?)	39	32	26.33	75	32	03.54
Elsinborough (3) (1881). 90 yards N. of last point	39	32	27.48	75	32	03.46
Alloway. (See Alloway above)	39	30	07.97	75	31	50.20
Alloway (2). Pine stub, 174 yards above mouth of Alloway's Creek	39	30	08.53	75	31	48.25
Alloway (3)	39	30	15.97	75	31	48.92
BURDEN. (See Burden above)	39	31	48.93	75	22	52.85
Stony (?)	39	27	33.11	75	31	09.25

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
SALEM COUNTY—Continued.	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Stony (2) (?)	39	27	47.42	75	31	12.55
Stony (3). Drain-pipe planted 5 feet from high-water mark. Stony Point. (1882)	39	28	01.83	75	31	16.12
Round Island. Buried cone in marsh. (1840) (?)	39	25	22.02	75	27	33.17
Round Island (2)	39	25	27.04	75	27	36.01
Sneed (?) 1882)	39	27	32.96	75	31	01.94
Cove (?) (1882)	39	26	13.73	75	28	18.14
Pot. Drain-pipe 20 feet back from high-water mark. (1882)	39	29	06.11	75	31	27.73
Arnold. Arnold's Point (?) (1840)	39	23	18.03	75	25	59.93
Arnold (2)	39	23	17.37	75	25	55.00
Arnold (3). Arnold's Point. Drain-tile planted in marsh 80 yards back from shore-line. (1881)	39	23	18.65	75	25	54.34
Round. Drain-tile planted in marsh. (1882)	39	25	36.85	75	27	39.52
Fort Delaware (2), Del. (1875)	39	35	20.30	75	34	04.05
Stow (?) (1882)	39	22	50.27	75	24	51.89
New (?) (1882)	39	24	09.65	75	26	35.13
Fort Delaware, Del. (See above)	39	35	22.04	75	34	08.60
Reedy Island Light-house (1881)	39	30	03.37	75	34	08.76
Delaware City Presbyterian Church spire, Del. (1840)	39	34	41.37	75	35	37.30
Eldridge's Hill, 225 yards S. W. of Hayne's house, at Point Airy. (V.)	39	39	45.3	75	18	24.3
Daretown. Church spire. (V.)	39	36	05.2	75	15	37.0
Mt. Pleasant. On hill, S. side of East Lake, S. E. of Woodstown. (V.)	39	38	22.8	75	18	32.0
Centerton. (V.)	39	31	45.3	75	07	44.4
Elmer. (V.)	39	34	57.5	75	11	12.7
Jericho. (V.)	39	29	19.8	75	21	50.2
New Boston. (V.)	39	31	17.9	75	17	10.2
COLSON'S. 1 mile S. E. of Daretown. (B.)	39	35	37.93	75	14	41.77
Whig Lane. 1½ miles E. of village. (B.)	39	38	37.82	75	12	12.11
Salem Church spire. (B)	39	34	24.01	75	27	59.45
Port Penn Range Light, Pa. (B.)	39	30	40.43	75	36	33.80
Finn's Point Range Light. (B.)	39	37	01.42	75	32	03.12
Quinton Church spire. (B.)	39	32	41.78	75	24	44.59
SOMERSET COUNTY.						
Bessel's Spheroid—						
Bound Brook. Pile of stones on brow of First Mountain. (a. 1851)	40	34	56.66	74	31	37.57
Mine Mount. Bar of iron projecting 3 inches on summit, 2 miles W. of Bernardsville. (B.)	40	43	16.35	74	36	00.58
North Branch (?) (B.)	40	35	52.65	74	40	33.58

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
SOMERSET COUNTY—Continued.	Deg.	Min.	Sec.	Deg.	Min.	Sec.
MT. HOREB. Copper bolt in ledge on summit, ½ mile S. W. of church. (B.)	40	36	39.37	74	33	56.57
Raritan. Woolen mill chimney. (B.)	40	33	52 02	74	37	37.32
Somerville. First Ref. Church spire. (B.)	40	34	03.78	74	36	21.72
Middlebush. Church spire. (B.)	40	29	47.17	74	31	23.11
East Millstone. Ref. Church cupola. (B.)	40	30	07.44	74	34	27.65
Clarke's Spheroid. Difference			*+02.7*			*+19.7*
Lamington. Church spire. (V.)	40	39	38.2	74	43	72.2
Pluckamin. Church spire. (V.)	40	38	52.6	74	38	32.7
Bedminster. Church cupola. (V.)	40	40	14.7	74	38	43.2
North Branch. Ref. Church spire. (V.)	40	35	56.6	74	40	22.4
SUSSEX COUNTY.						
Bessel's Spheroid—						
HIGH POINT. Copper bolt in ledge on summit of Blue Mountain, 1¼ miles from New York line. (B.)	41	19	12.74	74	39	23.38
Centerville. On hill, ¾ mile W. of village. (B.)	41	12	51.57	74	50	09.99
CULVER'S GAP. Copper bolt, first summit, S. W. of gap. (B.)	41	10	18.49	74	47	22.43
Deckertown. Presb. Church spire. (B.)	41	12	36.60	74	36	03.87
Decker Pond. Blazed spruce on hill, E. side of pond. (B.)	41	12	11.84	74	31	42.65
Glenwood. Blazed spruce on hill, 1 mile N. W. of village. (B.)	41	15	24.81	74	29	57.91
Hamburgh. Church spire. (B.)	41	09	06.48	74	34	13.69
Beaver Run. Blazed hickory on hill, 1½ miles W. of village. (B.)	41	09	18.50	74	38	27.17
East and West Jersey Line (on Blue Mountain). (B.)	41	08	44.15	74	50	40.08
Smith's Hill. Blazed chestnut on summit, 1½ miles N. of Newton. (B.)	41	04	55.05	74	44	30.17
Lafayette. A summit, 2 miles N. of village. (B.)	41	07	51.01	74	41	07.16
HAMBURGH. Copper bolt in ledge on summit, 2½ miles E. of village. (B.)	41	08	50.85	74	31	30.18
Franklin Furnace. Stack. (B.)	41	06	29.72	74	35	01.74
Catfish Pond. Summit, E. of pond. (B.)	41	01	54.92	74	59	30.59
Newton. Presbyterian Church spire. (B.)	41	03	24.80	74	44	59.00
Woodport. Cross on boulder on summit, ½ mile W. of Dodge mine. (B.)	41	00	37.55	74	35	10.36
Sparta. Cross on rock on summit, 1½ miles S. of Sparta. (B.)	41	00	55.96	74	37	56.04
Clarke's Spheroid. Difference			*+02.5*			*+19.6*
Lemon's house. W. of Swartswood. (V.)	41	04	52.6	74	51	42.4

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
SUSSEX COUNTY—Continued.	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Hardwick. Church cupola. (V.)............	40	59	44.1	74	51	39.0
Tranquility. Church spire. (V.)...	40	56	38.7	74	48	19.0
Andover, ¼ mile W. of village. (V.)........	40	59	09.8	74	44	49.4
Milford flag, Pa. Hill just N. E. of village. (V.)..	41	19	44.7	74	47	36.2
UNION COUNTY.						
Bessel's Spheroid—						
SPRINGFIELD. Pile of stones just E of old fence line, Roll's Hill, 2 miles S. of summit. (1817)..................................	40	41	19.44	74	21	05.44
Sayre. Hill, 2 miles N. E. of Cranford (?) (a. 1851)......................................	40	40	43.56	74	16	57.58
Elizabethtown. Spire of First Presbyterian Church. (a. 1851).......................	40	39	42.84	74	12	36.97
Randolph. On drift hill, E. of Plainfield (?) (a. 1851)..........................	40	36	41.81	74	23	20.32
Rahway. Spire of First Presbyterian Church. (a. 1851)..	40	36	51.04	74	16	32.11
Wynant. (a. 1859)...............................	40	32	55.28	74	13	58.89
Bird (?) (a. 1851)..................	40	39	03.13	74	10	08.69
Elizabethport. Presbyterian Church, white spire. (a. 1859)....................	40	38	49.75	74	11	08.24
Clarke's Spheroid. Difference..................			*+02.7*			*+19.7*
SPRINGFIELD. Roll's Hill, as above. (1817)	40	41	22.15	74	21	25.19
Sayre. (a. 1851)............................	40	40	46.27	74	17	17.35
Elizabethtown. Presbyterian Church, same as above. (1885)........................	40	39	45.55	74	12	56.77
Oil Cloth Co.'s chimney. Southern part of Elizabethport. (1885)	40	38	45.96	74	11	45.84
Staten Chemical Co.'s chimney. Near Bay Way, west bank of Arthur Kill. (1885)	40	37	55.90	74	12	15.47
Standard Chemical chimney. West bank of Arthur Kill. (1885)...........................	40	36	54.00	74	12	21.73
Wynant (2). Hickory stub and buried bottle, Wynant's land, near Tremley R. R. station. (1885)..	40	36	27.11	74	13	11.48
Westfield. Presbyterian Church spire. (V.)	40	39	14.1	74	20	52.7
Cranford. Presbyterian Church spire. (V.)	40	39	28.1	74	18	11.6
Roselle. Flag-staff. (V.)......................	40	39	37.0	74	15	50.4
Elizabeth. First Presbyterian Church spire. (V.)..	40	39	45.6	74	12	56.8
Elizabeth. St. Mary's Church spire. (V.)..	40	39	29.9	74	13	07.8
Washington Rock (North rock). (V.)......	40	36	45.7	74	28	20.9
Netherwood. Hotel. (V.)....................	40	37	33.7	74	24	00.4
Dunellen. Spire. (V.)..........................	40	35	39.9	74	27	50.2
New Dover. Spire. (V.).......................	40	35	07.2	74	20	26.4

Table of Geographical Positions—Continued.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
UNION COUNTY—Continued.	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Rahway. First Presbyterian Church spire. (V.)	40	36	53.8	74	16	51.8
Rahway. Second Presbyterian Church spire. (V.)	40	36	31.8	74	16	34.1
Linden. Reformed Church spire. (V.)	40	38	02.6	74	15	32.2
Linden. Episcopal Church spire. (V.)	40	37	39.7	74	15	07.0
Bay Way. Staten Chemical Co.'s chimney (V.)	40	37	56.0	74	12	15.3
WARREN COUNTY.						
Bessel's Spheroid—						
Delaware Water Gap. Brow of Mount Tammany. (B.)	40	58	05.12	75	06	23.27
Danville. Blazed white-oak on summit, 1 mile W. of village. (B.)	40	52	09.43	74	55	53.36
Hackettstown. Blazed rock-oak on summit, 2 miles W. of town. (B.)	40	51	05.48	74	51	59.91
MONTANA. Stone monument, ½ mile S. E. of village. (B.)	40	45	50.08	75	03	17.38
Clarke's Spheroid. Difference			*+02.6*			*+19.5*
Hope. Church spire. (V.)	40	54	31.9	74	58	11.7
Warrenville. 1 mile S. W. of village. (V.)	40	53	53.0	74	50	21.6
Jenny Jump Mountain. (V.)	40	52	02.2	74	59	20.8
Belvidere. Presbyterian Church spire. (V.)	40	49	36.6	75	04	42.9
Mt. No More. (V.)	40	48	03.8	75	01	36.4
White Hall. ¾ mile S. W. of cross-roads. (V.)	40	42	29.4	74	54	00.6
Easton. Court House spire. (V.)	40	41	18.0	75	13	03.7
Washington. Old chimney, bank of canal. (V.)	40	45	55.6	74	59	17.2
Pohatcong Mountain. (V.)	40	42	28.4	75	03	05.2

BENCH-MARKS.

In the following list all elevations are in feet and refer to mean sea level at Sandy Hook, as determined by a series of observations by the United States Coast and Geodetic Survey, extending from October 21st, 1875, to October 31st, 1881, in a continuous series. Bench-marks marked U. S. C. S., are from the line of geodetic levels from Sandy Hook, through Phillipsburg, run in 1881, by the United States Coast and Geodetic Survey. All others were determined by the State Survey. Those described as "monuments," and numbered in the descriptions, are masses of masonry imbedded in the ground, with a rounded granite post, the summit of which is the bench-mark, projecting from the top, and usually raised about six inches above the surface of the ground. A detailed description of these monuments, and the manner of setting them, was given on pages 14 and 15 of the annual report of the State Geologist for 1885.

The objects of the primary lines of levels, run in connection with the Topographic Survey of the State, may be stated as follows: (1) To insure accuracy in the determination of elevations for topography; (2) To ascertain the exact elevation of a series of permanent bench-marks, above mean sea level, by which means any future elevation or depression of the earth's crust may be detected and measured; (3) To furnish a series of reliable bench-marks throughout the State for the use of city and railroad surveys and for all engineering purposes, in order that such surveys may constantly add to the general fund of information as to the surface of the State, and that the value of the Topographic Survey as an aid to such surveys may be increased by having all referred to the same datum plane.

In order that the full benefit of this work may be felt, it is desirable that all railroad and city engineers shall co-operate and refer their levels to the common datum.

Atlantic County.

ABSECON. . . . . Eleva., 24.232 ft.

Elevation of underground mark, 19.561 ft.

This monument (No. 10) is located in the small triangular grass plat where the main road from Philadelphia and Egg Harbor City enters the main shore road from Absecon to Leeds' Point. It is set

in the center line of the Philadelphia road and 12.75 feet west of the center line of the shore road (the road being 49.5 feet wide). It is also 64 feet from the corner of old house standing in yard at the west street corner; 62.6 feet from corner of house on the south street corner, and about in range with its northeast end, and 131.9 feet from corner of new house on the east street corner.

The top is level with the surface of ground.

ABSECON. . . . . Eleva., 30.66 ft.

On east end of stone door-sill of Methodist Episcopal Church, about 220 yards west of the above primary monument.

ATLANTIC CITY. . . . . Eleva., 8.954 ft.

On an old United States Coast Survey tidal bench-mark cut on northwest side of base of Absecon light-house. It is under the south end of a window-sill, and is a small shelf cut in the convex water-table, with the letters "U. S. C. S." cut above it.

ATLANTIC CITY. . . . . Eleva., 10.184 ft.

A cross cut on north end of stone door-sill of Atlantic City National Bank, at northerly corner of Atlantic and North Carolina avenues, the door being on Atlantic avenue.

DA COSTA. . . . . Eleva., 80.14 ft.

A cross cut 0.40 feet from each edge of stone at southeast corner of coping of southeasterly culvert wall on Camden and Atlantic railroad, one mile west of Da Costa station.

DOUGHTY'S. . . . . Eleva., 25.75 ft.

A cross cut on coping stone at east end of south wall of culvert on Camden and Atlantic railroad, 60 yards east of 11–49 mile-post, just west of Doughty's station. The cross is 0.75 feet from the corner.

EGG HARBOR CITY. . . . . . . Eleva., 56.573 ft.

Elevation of underground mark, 52.511 ft.

This monument (No. 17) is located on southwest side of Agassiz street and the southeast side of Buffalo avenue, 5 feet from the street and avenue lines, and 3 feet inside of center of hedge, which stands

2 feet from the street and runs around the School Park. There are three parks on the southwest side of Agassiz street, the School Park being in the middle. Excursion Park lies northwest of Buffalo avenue; School Park lies southeast of it and runs to Agricultural Fair Grounds, and these Fair Grounds extend from School Park to St. Louis avenue.

The monument is 251.8 feet to the northwest of the north corner of the school-house, 26.5 feet from center of a large maple tree on Buffalo avenue, 12.45 feet from center of another tree standing to northeast of former, and 44.93 feet from center of large maple tree standing on southwest side of Agassiz street.

Egg Harbor City. . . . . . . Eleva., 60.27 ft.

A cross cut on south corner of upper outside flagstone step in front of side door of brick store on the north corner of Philadelphia avenue and Agassiz street.

Hammonton. . . . . Eleva., 102.82 ft.

A cross cut on the water-table on south side of front door, and 3.1 feet from corner of three-story concrete store standing on east side of Bellevue street, and on north side of Camden and Atlantic railroad.

Leeds' Point. . . . . Eleva., 52.691 ft.

Elevation of underground mark, 48.648 ft.

This monument (No. 9) is located just west of the hotel at forks of roads to Port Republic and to Absecon. It is at the intersection of the center line of Absecon road with the south line of Port Republic road. The following measurements were taken: To northeast corner of store at southwest corner of roads, 52.5 feet; to center of small cedar north of and opposite the store, 69.2 feet; to center of wild cherry tree at southeast road corner, 22.5 feet, and to center of maple tree standing on the south side of Point road, east of forks of roads, 75.9 feet.

The top of this monument is just below the surface of the road.

Mays Landing. . . . . Eleva., 19.89 ft.

This bench-mark is a cross cut on west end of stone door-sill of front door of Atlantic county court-house.

MAYS LANDING. . . . . Eleva., 20.66 ft.

This bench-mark is the arrow-head engraved on the brass top of the south "true meridian" post standing in the court-yard.

MAYS LANDING. . . . . Eleva., 18.82 ft.

This bench-mark is a cross cut on east end of stone door-sill of front or north door of the American Hotel, just southeast of court-house.

MOUNT PLEASANT. . . . . . . Eleva., 13.96 ft.

A cross cut on bluestone door-sill of northerly door at east side of Atlantic City water works pumping station, just north of Mount Pleasant.

SOMERS' POINT. . . . . Eleva., 26.160 ft.

Elevation of underground mark, 21.535 ft.

This monument (No. 11) is placed on the brow of the hill in front of the old Somers homestead, a brick building on the shore road just south of the railroad crossing, at Somers' Point. It is set in the center line of the road which runs to the west and is in the produced line of the curb along the northerly side of the street running down to the railroad depot, and 29 feet from the corner of the curb at the northwest corner of the streets, said corner bearing south 37° east from the monument. The southeast corner of the Somers homestead bears north 5° west, 75 feet distant, and a large cedar tree near the southwest street corner bears south 60° west, 53.5 feet distant. The center of the railroad track, where it crosses the shore road, is about 160.5 feet from the monument.

(NOTE.—On account of a change of the grade of the streets, No. 11 was reset May 31st, 1887, and the above description and elevations apply to its new position.)

Bergen County.

ALLENDALE. . . . . Eleva., 270.39 ft.

A cross cut on the outside corner of the second step from the top of the east end of the retaining wall of the north abutment of the New York, Lake Erie and Western railroad bridge over a brook, about 300 yards south of the station.

BLAUVELTVILLE, N. Y. . . . . . Eleva., 182.80 ft.

A cross cut on the outside corner of the west end of the south abutment of the road bridge over the Piermont branch of the New York, Lake Erie and Western railroad.

CLOSTER. . . . . Eleva., 40.48 ft.

This bench-mark is on the east end of the sill of the most easterly of two doors in the south side of the brick building opposite the Northern Railroad of New Jersey station.

CLOSTER. . . . . Eleva , 40.00 ft.

A cross cut on the east corner of the sill of the front door of M. Kohler's feed store.

DEMAREST. . . . . Eleva., 38.87 ft.

A cross cut on the south end of the sill of the front door of the Northern Railroad of New Jersey station.

DUNDEE LAKE. . . . . Eleva., 41.14 ft.

This bench-mark is on the New York, Susquehanna and Western railroad bridge crossing the lake. The point is a cross on the northwest corner of the iron bed-plate on which rests the most easterly truss on the north side of the track.

ENGLEWOOD. . . . . Eleva., 24.05 ft.

A cross on the north end of the sill of the front door of the ladies' waiting-room of the Northern Railroad of New Jersey station.

ENGLEWOOD. . . . . Eleva., 44.84 ft.

A cross on the southwest end of the sill of the door of the post-office, at the northwest corner of Palisade avenue and Engle street.

HACKENSACK. . . . . Eleva., 12.50 ft.

A cross cut on the west end of the sill of the main front door of the First Reformed Church, on Court street.

HACKENSACK. . . . . Eleva., 14.22 ft.

A cross cut on the west end of the sandstone sill of the main front door of the Bergen county court-house.

HIGHWOOD. . . . . Eleva., 48.95 ft.

A cross cut on the northeast corner of coping of the retaining wall at the east end of the south abutment of the Northern Railroad of New Jersey bridge over a brook, about 500 yards south of the station.

HOHOKUS. . . . . Eleva., 194.69 ft.

A cross cut on the southwest corner of the coping of the west parapet of the New York, Lake Erie and Western railroad culvert over Hohokus creek.

MONSEY, N. Y. . . . . Eleva., 527.29 ft.

This bench-mark is on the summit of the large guard-stone at the northwest corner of the freight station.

NANUET, N. Y. . . . . Eleva., 297.98 ft.

A cross cut on the south end of the stone sill of the front door of William Hutton, Jr.'s, brick store, near the railroad station.

NORDHOFF. . . . . Eleva., 9.87 ft.

This bench-mark is on the north end of the sill of the most northerly window in the front of the lodge at the entrance of Hon. W. W. Phelps' Teaneck estate.

ORANGETOWN, N. Y. . . . . . . Eleva., 113.82 ft.

A cross cut on the east corner of the coping on top of and at the extreme south end of the long abutment of the bridge carrying the Piermont branch of the New York, Lake Erie and Western railroad over the West Shore railroad.

PALISADES MONUMENT. . . . . . Eleva., 460.21 ft.

This bench-mark is on the summit of the State line monument, on top of the Palisades.

PALISADES MONUMENT. . . . . . Eleva., 453.08 ft.

This bench-mark is a cross cut on a rounded knob of the bed-rock 7.8 feet southwest of the monument.

PASSAIC JUNCTION. . . . . . . Eleva., 53.20 ft.

A cross cut on the southeast corner of the lowest step at the east end of the north abutment of the bridge carrying the Bergen County railroad (Erie) over the New York, Susquehanna and Western railroad.

RAMSEY'S. . . . . Eleva., 344.25 ft.

A cross cut on the east end of the sill of the most easterly window in the north end of John Y. Dater's brick dwelling, near the station.

RIDGEFIELD. . . . . Eleva., 14.35 ft.

A cross cut on the south end of the sill of the front door of the ladies' waiting-room of the Northern Railroad of New Jersey station.

RIDGEFIELD PARK. . . . . . . Eleva., 6.77 ft.

This bench-mark is on the northwest corner of the west end of the culvert under the West Shore railroad, one-third mile north of the village.

RIDGEWOOD. . . . . Eleva., 140.33 ft.

A cross cut on the west end of the stone sill of Abraham J. Zabriskie's brick building (now used as a feed store), near the station.

SPRING VALLEY, N. Y. . . . . . Eleva., 448.94 ft.

A cross cut on the east end of the front door-sill of the Reformed Church.

SUFFERN, N. Y. . . . . Eleva., 283.50 ft.

This bench-mark is the top of the State line monument, between the two tracks of the New York, Lake Erie and Western railroad, about three-quarters mile south of Suffern.

SUFFERN, N. Y. . . . . Eleva., 287.45 ft.

This bench-mark is the top of the new fifteenth mile-stone of the State line.

TALLMANS, N. Y. . . . . . . Eleva., 482.58 ft.

A cross cut on the top of a large boulder in the railroad cut on the north side of the track, 25 yards west of a bridge and 100 yards east of the station.

TENAFLY. . . . . Eleva., 48.06 ft.

A cross cut on the south end of the sill of the north front door of the Northern Railroad of New Jersey station.

Burlington County.

BIRMINGHAM. . . . . Eleva., 31.29 ft.

On the most southerly of two bolts on the top of northwest wing-wall of bridge over race, 100 yards north of Birmingham railroad station.

BORDENTOWN. . . . . Eleva., 15.53 ft.

A triangle cut on the west end of stone door-sill at the south entrance to fire-room of Bordentown Reservoir and Water Co.'s pump-house, near the outlet lock of the Delaware and Raritan canal.

BORDENTOWN. . . . . Eleva., 24.17 ft.

A triangle cut on coping-stone at the east end of the south abutment of railroad bridge over roadway, just north of lower Bordentown railroad station.

BURLINGTON. . . . . Eleva., 12.53 ft.

Cross cut on dressed stone at west end of door-sill of main entrance to Baptist Church at northwest corner of Broad and Stacy streets.

BURLINGTON. . . . . Eleva., 11.30 ft.

A cross cut on northwest corner of projecting ledge of iron post at northwest corner of iron bridge over Assiscunk creek, on Main street.

DEACON'S. . . . . Eleva., 80.56 ft.

A triangle cut on water-table at southwest corner of brick school-house, on east side of turnpike, three-eighths mile southeast of Deacon's station.

MOUNT HOLLY. . . . . Eleva., 185.47 ft.

On the northwest corner of granite monument, located on the summit of Mount Holly, and which marks the United States Coast and Geodetic Survey triangulation point, Mount Holly.

MOUNT HOLLY. . . . . Eleva., 16.88 ft.

On northwest corner of door-sill of National Bank, on northeast corner of Main and Mill streets.

MOUNT HOLLY. . . . . Eleva., 42.97 ft.

On the northwest corner of marble door-sill of main entrance to Burlington county court-house.

PEMBERTON. . . . . Eleva., 39.23 ft.

On the southwest corner of granite block, upon which rests the south end of west iron arch of bridge over mill-pond, South Pemberton.

TUCKERTON. . . . . Eleva., 22.632 ft.

Elevation of underground mark, 17.972 ft.

This monument (No. 8) is set in the northwest corner of the Presbyterian churchyard, at the corner of Main and Cedar streets, 3.2 feet back from the front fence, being in line with the south fence line of Main street, west of Cedar street, and 3 feet east of the east line of Cedar street. It is 32.9 feet from the northwest corner of the church.

WHITE HILL. . . . . Eleva., 14.24 ft.

On a protuberance indicated by an arrow and the letters B. M., on the southeast corner of the flagstone coping of the northwest wall of bridge over ice-pond, on the road to Burlington, one mile west of White Hill.

Camden County.

CAMDEN. . . . . Eleva., 30.64 ft.

A cross cut on southeast end of highest step of main entrance to new Camden county court-house, on Federal street.

CAMDEN. . . . . Eleva., 21.23 ft.

A cross cut on north end of north door-sill on east side of station at junction of Camden and Atlantic and Pennsylvania railroads, at corner of Tenth and Market streets.

CAMDEN. . . . . Eleva., 34.53 ft.

On easterly corner of pedestal, over the builders' names (Krips & Shearman), of the soldiers' monument, on Haddon avenue, just north of city hall.

GLOUCESTER FERRY. . . . . . . Eleva., 5.91 ft.

A cross cut on southeast corner of slate slab on top of rubble wall, southeast of Gloucester ferry pier, and 56 yards in a southerly direction from Buena Vista Hotel.

KIRKWOOD. . . . . Eleva., 60.04 ft.

On cross on southeast corner of slate slab on south side of outlet of pond, on dam opposite railroad station.

MERCHANTVILLE. . . . . . . Eleva., 80.11 ft.

On the west end of marble door-sill (close by corner of brickwork), of the east front door of new railroad station.

WINSLOW. . . . . Eleva., 112.019 ft.
Elevation of underground mark, 107.779 ft.

This monument (No. 18) is located in the grass plat, 22.5 feet west of flag-pole. It is in the center line of road running south of New Jersey Southern railroad station, and is about in center line of roads running to Hammonton and Waterford. The following measurements were taken from the monument: North 46° 30′ east, 57 feet to large oak; north 6° 30′ west, 41 feet to another large oak; 123.25 feet to southeast corner of Hay & Co.'s store; 50 feet to corner of glass works fence; 55 feet perpendicularly to south line of road to New Germany; 58 feet to southwest street corner, and 73 feet to northeast corner of house on this southwest corner.

WINSLOW. . . . . Eleva., 112.76 ft.

A cavity cut in foundation at south corner of brick chimney, at south corner of Hay & Co.'s steam flour mill, at Winslow. An arrow-head points to it, and it is 1.8 feet above surface of ground.

Cape May County.

CAPE MAY COURT HOUSE. . . . Eleva., 19.498 ft.

Elevation of underground mark, 14.961 ft.

This monument (No. 14) is set in the east corner of Cape May county court-yard, 4 feet from the front or street fence, and 5 feet from the line fence between the court-yard and the M. E. church-yard. It is also 81.7 feet from the center of the south "true meridian" post, 62 feet from the north one, 54 feet from east corner of court-house and 42 feet from south corner of M. E. Church.

CAPE MAY CITY. . . . . . . Eleva., 10.876 ft.

This bench-mark is a cross cut on stone, under east corner of West Jersey railroad station.

CAPE MAY. . . . . Eleva., 6.409 ft.

Elevation of underground mark, 1.829 ft.

This monument (No. 15) is located on the Cape May light-house lot, just southeast of Cape May Point and about two miles west of Cape May City.

The Cape May and Sewell's Point railroad divides the light-house property into two parts.

The monument is set in the east corner of the south part, 2 feet from the line fence of the railroad and 2 feet from the southeast line of the lot. The United States Life Saving Station stands on the south and the light-house on the north part of the lot. The corners of the lot are marked by square granite posts.

Beginning at the southwest corner of lot, the line runs south 62° 40′ east, 206.8 feet to south corner; thence north 28° 30′ east, 214.25 feet to a point 2 feet southeast of the monument, the whole distance to the next corner being 424.6 feet. From the first-mentioned corner the magnetic bearing is north 1° 40′ east, from the second north 10° west, and from the third north 28° west, to the center of the light-house.

CAPE MAY. . . . . Eleva., 8.244 ft.

On northwest corner of square stone monument in southeast corner of light-house lot.

CAPE MAY. . . . . Eleva., 13.187 ft.

On United States Coast Survey tidal bench-mark of 1867, cut on east side of projecting water-table at base of Cape May light-house.

COLD SPRING. . . . . Eleva., 20.70 ft.

A cross cut on north end of northerly stone door-sill of Cold Spring Presbyterian Church (brick).

OCEAN CITY. . . . . Eleva., 10.298 ft.

Elevation of underground mark, 5.320 ft.

This monument (No. 12) is set about 3 feet south of the north corner of the new life-saving station lot, which runs from the corner of Atlantic avenue and Fourth street, northeasterly 100 feet along said avenue, and southeasterly 130 feet along said street. It is set about 2.1 feet southwest of the northeast line of the lot. It is about 400 feet from high-water line at this time (1887).

SEA ISLE CITY. . . . . Eleva., 5.193 ft.

Elevation of underground mark, 1.130 ft.

This monument (No. 13) is set just south of the north corner of the new United States light-house lot, which is located on the east side of the Sea Isle and Ocean City railroad, in the south corner of block 62, and is bounded on the southeast by the beach, and on the southwest by Whelen street.

The monument is set 2 feet from the northwest line of the lot and 2 feet from the northeast line, which makes it 2.8 feet from the north corner of the lot.

SEA ISLE JUNCTION. . . . . . . Eleva., 15.86 ft.

This bench-mark is on the frog (1 foot from its point) of the switch just north of the station.

Cumberland County.

BAY SIDE. . . . . Eleva., 7.51 ft.

This bench-mark is on root of oak tree in edge of grove near turntable of New Jersey Southern railroad.

BRIDGETON. . . . . Eleva., 29.61 ft.

This bench-mark is a cross cut on north end of store door-sill of east door of Bridgeton water works, on east side of East Lake.

BRIDGETON. . . . . Eleva., 22.41 ft.

This bench-mark is a cross cut on east end of door-sill of main front entrance of First Baptist Church, on Commerce street.

BRIDGETON. . . . . Eleva., 54.25 ft.

This bench-mark is a cross cut on west end of large upper stone step of front entrance of stone Presbyterian church, on Commerce street, in West Bridgeton.

NEAR BRIDGETON. . . . . . . Eleva., 91.00 ft.

This bench-mark is on the east rail of West Jersey railroad, and the south rail of New Jersey Southern railroad, at their crossing about two miles north of Bridgeton.

MILLVILLE. . . . . Eleva., 33.45 ft.

This bench-mark is a cross cut on the water-table on southwest corner of Millville National Bank, on northeast corner Main and Second streets.

MILLVILLE. . . . . Eleva., 28.79 ft.

This bench-mark is a cross cut on south end of stone door-sill of main entrance to Workingmen's Institute.

VINELAND. . . . . Eleva., 108.10 ft.

This bench-mark is a cross on north end of stone door-sill of north door on west side of Vineland station of West Jersey railroad.

VINELAND. . . . . Eleva., 118.05 ft.

This bench-mark is a cross cut on east end of front or north door-sill of First Baptist Church, on south side of Landis avenue, just west of Ninth street.

VINELAND. . . . . Eleva., 115.76 ft.

This bench-mark is a cross cut on east end of stone door-sill of First M. E. Church, on northeast corner of Landis avenue and Seventh street.

Essex County.

BELLEVILLE. . . . . Eleva., 32.85 ft.

A cross cut on the top of the west wall of the bridge over Second river at Belleville avenue.

BLOOMFIELD. . . . . Eleva., 130.33 ft.

A cross cut on the highest of a series of steps, at the northeast end of the east abutment of the New York and Greenwood Lake railroad bridge over the canal. The point is under the truss and 4 feet below the track.

BLOOMFIELD. . . . . Eleva., 141.21 ft.

A cross cut on the west sill of the main front door of the old Presbyterian church.

BLOOMFIELD. . . . . Eleva., 181.06 ft.

A cross cut at the southeast corner of the east end of the north abutment of the first road bridge above Morris canal plane No. 11.

BLOOMFIELD. . . . . Eleva., 178.17 ft.

This bench-mark is on the west abutment of the bridge over the Morris canal, on the road from Watchung to Avondale, about 2 miles north of Bloomfield. The point is marked by a cross cut on the lowest step at the south end of the abutment.

BROOKDALE. . . . . Eleva., 177.52 ft.

This bench-mark is on the west abutment of the bridge over the Morris canal, on the road from Watchung to Peru, 3 miles north of Bloomfield. The point is a cross cut in the lowest step of the retaining wall at the north end of the abutment.

NEWARK. . . . . Eleva., 24.62 ft.

A cross cut on the south end of the sill of the front door of the German Methodist Church, at the northeast corner of Walnut and Mulberry streets.

NEWARK. . . . . Eleva., 42.12 ft.

A cross cut on the west end of the sill of the window at the south end of the custom-house. The point is 4.5 feet above the pavement.

NEWARK. . . . . Eleva., 109.92 ft.

A cross cut on the stone at the south end of a bridge over the Morris canal on Summit street, at the upper end of the inclined plane.

NEWARK. . . . . Eleva., 54.99 ft.

A cross cut on the southeast corner of the base of the most northerly of two large columns at the main entrance in the east front of the Essex county court-house, on Market street.

NEWARK. . . . . Eleva., 119.10 ft.

This bench-mark is on the east abutment of the bridge carrying Sussex avenue over the Morris canal. The point is a cross on the northeast corner of the stone on which the east end of the north truss rests.

Gloucester County.

SWEDESBORO. . . . . Eleva., 40.43 ft.

This bench-mark is a cross cut on north end of marble door-sill of front door of brick M. E. church, on northwest corner of Main street and Railroad avenue.

SWEDESBORO. . . . . Eleva., 44.822 ft.

This bench-mark is a cross cut on north end of door-sill of National Bank.

WOODBURY. . . . . Eleva., 58.11 ft.

This bench-mark is a cross cut on south end of stone door-sill of front door of brick Presbyterian church, on Main street.

WOODBURY. . . . . Eleva., 62.32 ft.

This bench-mark is a cross cut on southeast corner of the lowest of three marble bases of soldiers' monument in front of court-house.

WOODBURY. . . . . Eleva., 37.28 ft.

This bench-mark is a cross cut on south end of stone door-sill of front entrance of G. G. Green's brick laboratory, which faces the railroad just south of West Jersey railroad depot.

Hudson County.

BELMONT. . . . . Eleva., 11.63 ft.

A cross cut on the lowest sandstone step at the north end of the masonry of the west pier of the bridge carrying the West Shore railroad over the Northern Railroad of New Jersey.

EAST NEWARK. . . . . Eleva., 26.03 ft.

A cross on the west end of the stone sill of the front door of the small brick office building, at Peter Hauk & Co.'s brewery, on Harrison avenue, opposite Washington street.

JERSEY CITY. . . . . Eleva., 100.63 ft.

A cross cut on the sandstone water-table of the Hudson county court-house. The point is on the Newark avenue face of the building, 5.1 feet from the south corner, and 0.8 foot above the stone flooring of the portico.

JERSEY CITY. . . . . Eleva., 99.65 ft.

A cross cut on the east end of sandstone sill of the most westerly of two doors in the Newark avenue front of the Hudson county jail, opposite Oakland avenue.

JERSEY CITY. . . . . Eleva., 104.39 ft.

A cross cut on the north end and near the outer edge of the sill of the main front door of the First Baptist Church, on Summit avenue.

JERSEY CITY. . . . . Eleva., 94.93 ft.

A cross cut on the south corner of upper large square stone step at the main entrance (on Summit avenue) of the Westminster Presbyterian Church, at the east corner of Summit and Magnolia avenues.

JERSEY CITY. . . . . Eleva., 21.75 ft.

A cross cut on the south end of the sill of the front door of the post-office, Washington street.

JERSEY CITY. . . . . Eleva., 6.99 ft.

A cross cut on the outside of the top of the south wall (at the west corner of the lock wall) of the Morris canal lock No. 22. This lock is at Washington street, and the bench-mark is also one of the canal levels.

NEW DURHAM. . . . . Eleva., 7.91 ft.

A cross cut on the lowest of a series of steps at the west end of the north abutment of the bridge carrying the road over the West Shore railroad, at the station.

Hunterdon County.

ANNANDALE. U. S. C. S. . . . . Eleva., 355.049 ft.

This bench-mark is about 1 mile east of Annandale station (New Jersey Central railroad). It is the bottom surface of a square cavity cut on a projecting stone, about the center of the north abutment of overhead road bridge. This bench-mark is a little below the level of the railroad track. The stone is hard, blue limestone.

BLOOMSBURY. U. S. C. S. . . . . Eleva., 326.180 ft.

This bench-mark is the bottom of a square cavity cut on top stone of northwest corner of stone bridge (railroad) over wagon road, one-quarter mile west of Bloomsbury station, New Jersey Central railroad.

It is marked thus— B. ▭ M.
1881.

FLEMINGTON. . . . . Eleva., 187.45 ft.

This bench-mark is a cross cut on south end of door-sill of front entrance of court-house.

FLEMINGTON. . . . . Eleva., 186.29 ft.

This bench-mark is on top of brass head of southern "true meridian" post in front of court-house.

FLEMINGTON. . . . . Eleva., 171.26 ft.

This bench-mark is a cross cut on west end of door-sill of door in southwest corner of stone Presbyterian church, at forks of street.

LAMBERTVILLE. . . . . Eleva., 70.01 ft.

This bench-mark is a cross surrounded by a triangle on the north-east corner of large corner-stone on north end of west wall of lock on canal feeder.

LAMBERTVILLE. . . . . Eleva., 72.87 ft.

This bench-mark is a cross cut on south end of door-sill of the center or ladies' waiting-room door, on east side of railroad station.

LAMBERTVILLE. . . . . Eleva., 81.38 ft.

This bench-mark is a cross cut on east end of stone door-sill under portico of Baptist church, on Bridge street.

MOUNT AIRY STATION. . . . . . Eleva., 137.35 ft.

This bench-mark is a cross cut on fourth stone step from bottom of south abutment of bridge over highway, on west side of railroad.

RINGOES. . . . . Eleva., 240.85 ft.

This bench-mark is a cross cut on second stone step from the bottom of north abutment on west side of railroad track, at road crossing just north of depot.

Mercer County.

MILLSTONE AQUEDUCT. . . . . . Eleva., 58.940 ft.

A triangle cut in the center of the memorial plate on top of the south end of the west abutment of aqueduct carrying the Delaware and Raritan canal over the Millstone river, two miles south of Kingston.

PRINCETON. . . . . Eleva., 208.510 ft.

Center of triangle cut on the north end of the door-sill at west entrance to the Hall of Science, on college campus.

PRINCETON. . . . . Eleva., 217.180 ft.

A cross cut on top of water-table at the northeast corner of East College, on college campus.

TITUSVILLE. . . . . Eleva., 63.23 ft.

This bench-mark is a cross cut on east end of stone door-sill of front door of brick Presbyterian church.

TRENTON. . . . . Eleva., 54.250 ft.

On broad water-table, 3.2 feet above pavement, in re-entrant angle of stone moulding. The point is indicated by an arrow-head, and is 1.1 feet south from produced line of south jamb of the most southerly window on the west side of the United States government building, at the northeast corner of Montgomery and State streets.

TRENTON. . . . . Eleva., 56.36 ft.

A triangle cut on the coping of north side of stone pivot-pier of railroad bridge over canal at entrance of feeder, one block north of Perry street.

TRENTON. . . . . Eleva., 52.610 ft.

A triangle cut on the northeast corner of the most northerly coping-stone of west lock wall of Prison lock of Delaware and Raritan canal.

WASHINGTON'S CROSSING. . . . . . Eleva., 57.01 ft.

This bench-mark is a cross cut on southwest corner of coping-stone on west end of wall on north side of outlet sluice of feeder, at south end of station platform.

Middlesex County.

JAMESBURG. . . . . Eleva., 51.41 ft.

A cross cut on the west end of the stone door-sill of the First National Bank.

JAMESBURG. . . . . Eleva., 48.62 ft.

This bench-mark is on the southwest corner of the bed-stone, under the east end of the south truss of the iron wagon bridge, 45 yards west of the Lower Jamesburg railroad station. It is marked by a cross inside of a triangle, cut in the stone.

JAMESBURG. . . . . Eleva., 72.51 ft.

A cross cut on the northeast corner of the square marble stone under the northeast corner post of the Jamesburg hotel.

KINGSTON. . . . . Eleva., 57.71 ft.

A triangle cut on the east edge of west wall of Delaware and Raritan canal lock.

METUCHEN. U. S. C. S. . . . . . Eleva., 83.641 ft.

This bench-mark is a slight circular concavity, bounded by a triangle, cut on the west end of the south wall (near base) of the stone bridge near Metuchen tank station of Lehigh Valley railroad. By means of this bridge the Pennsylvania railroad crosses over the Lehigh Valley railroad.

MONMOUTH JUNCTION. . . . . . Eleva., 87.39 ft.

A cross on the coping-stone over the center of the arch of stone culvert, on the east side of the main line of the Pennsylvania railroad, 170 yards north of the Monmouth Junction station.

MONMOUTH JUNCTION. . . . . . Eleva., 87.48 ft.

This bench-mark is on the head of the copper bolt surrounded by a square nut, on the northwest corner of the stone culvert on the west side of the main line of the Pennsylvania railroad, about 170 yards north of the Monmouth Junction station.

MORGAN STATION. U. S. C. S. . . . . Eleva., 5.611 ft.

This bench-mark is the surface of stone in center of triangle, cut on top of the southeast pier of the draw-bridge, at Morgan station, of New York and Long Branch railroad. The bridge crosses Cheesequake creek.

(This bench-mark has apparently settled. C. C. V.)

NEW BRUNSWICK. . . . . Eleva., 70.951 ft.

Elevation of underground mark, 65.709 ft.

This monument (No. 1) is on Rutgers College campus, at a distance of 35 feet, measured on a perpendicular from the face of the front wall of the main college building, the perpendicular being erected from the middle of front entrance door, which door is in the middle of south side of the building.

NEW BRUNSWICK. . . . . Eleva., 17.62 ft.

A cross cut on a large coping-stone at south end of lock-chamber and on the east wall of the second, or "deep" lock of the Delaware and Raritan canal.

NEW MARKET. U. S. C. S. . . . Eleva., 49.179 ft.

This bench-mark is the bottom of a square cavity, cut on top stone of south end of west abutment of a small railroad bridge about three-quarters mile west of New Market station, Lehigh Valley railroad, and 200 meters (656 feet) west of mile-post (13 miles to Perth Amboy).

It is marked thus— B. ▭ M.
XI.

PERTH AMBOY. U. S. C. S. . . . Eleva., 7.782 ft.

This bench-mark is between Perth and South Amboy, on one of the piers of the long bridge across Raritan bay. It is on the pier on which the north end of the draw-bridge rests (east side of track), and is, as usual, the bottom surface of a square cavity, 1 inch square and one-half inch deep.

F.
It is marked thus— B. ▭ M.
U. S. C. & G. S.
1881.

N. B.—This bench-mark has settled. Its elevation in 1886, is 7.53 ft. C. C. V.

PERTH AMBOY. . . . . Eleva., 60.600 ft.

Elevation of underground mark, 55.855 ft.

This monument (No. 2) is located in a triangular grass plat in the public park on the center line of High street, 97.75 feet southwesterly from its intersection with the center line of Market street. The intersection of said streets is marked by a sunken monument from which the city surveys start.

PERTH AMBOY. . . . . . . Eleva., 57.400 ft.

This bench-mark is on the east end of stone door-sill of Market street entrance of the city hall.

PERTH AMBOY. . . . . Eleva., 29.62 ft.

A cross cut on a slight shelf on the sixth stone from the north end of the second tier, above the surface of the ground, of the eastern abutment of the bridge carrying the New York and Long Branch railroad over the Pennsylvania railroad, about one and a half miles north of Perth Amboy.

SOUTH PLAINFIELD. U. S. C. S. . . Eleva., 63.860 ft.

This bench-mark is the bottom surface of a square cavity (1 inch square by one-third inch deep), cut on top of stone abutment at northwest corner of a small iron railroad bridge, about 150 meters (492 feet) east of South Plainfield station of Lehigh Valley railroad.

It is marked thus— B. ▭ M.

WOODBRIDGE. . . . . Eleva., 22.85 ft.

A cross cut on the water-table at the northeast corner of the Methodist church; over the corner-stone bearing the date "1870."

WOODBRIDGE. . . . . Eleva., 17.06 ft.

A cross cut on the north end of the stone sill of the south door on the east side of the Pennsylvania railroad station.

Monmouth County.

ASBURY PARK. . . . . Eleva., 22.184 ft.

On water-table at southwest corner, just over the corner-stone, of First M. E. Church, at corner of Grand and First avenues, Asbury Park.

ENGLISHTOWN. . . . . Eleva., 70.96 ft.

A cross cut on the southeast corner of the flag coping-stone on the east wing wall of the south abutment of the iron bridge over the Matchaponix at the Englishtown mill (between the village and the railroad station).

FARMINGDALE. . . . . Eleva., 71.70 ft.

On the most easterly intersection of rail in the frog at crossing of Freehold and Jamesburg and New Jersey Southern railroads.

FREEHOLD. . . . . Eleva., 186.63 ft.

A cross cut $2\frac{1}{2}$ inches south of the intersection of the three joints formed by the three most southerly stones in the south corner of the large triangular base of the Monmouth Battle-Field Monument. The cross is $2\frac{1}{2}$ inches south of the north apex of the stone which abuts on its south sides against the octagonal gun-pedestal, which is built at the south corner of the triangular base.

FREEHOLD. . . . . Eleva., 178.15 ft.

A cross cut on the east end of stone door-sill of the sheriff's office, being the most easterly of two doors in the middle of the front of Monmouth county court-house.

HIGHLAND STATION. U. S. C. S. . . Eleva., 7.637 ft.

This bench-mark is a granite post, projecting about 2 feet above surface of the ground; it is on west side of track of New Jersey Southern railroad, about three-quarters mile north of Highland station. About 150 meters (492 feet) southwest of it there is a small, deserted shanty. The center of the top surface of the stone is the bench-mark.

LAKE TAKANASSEE BRIDGE. . . . Eleva., 16.715 ft.

A cross cut on north end of west wing wall of the northern abutment at the foot of the iron post at end of railing of bridge over Lake Takanassee (Green's Pond), on Ocean avenue, near Life Saving Station No. 5, West End.

MANASQUAN. . . . . Eleva., 21.78 ft.

A cross cut on east end of sandstone door-sill of the First National Bank, on Main street, just east of entrance to South street.

MATAWAN. U. S. C. S. . . . . . Eleva., 55.083 ft.

This is the center of a triangle cut on the east corner of a flagstone in front of Benjamin Tuttle's front gate, Main street, Matawan. It is about one-third mile from the station of the New Jersey Central railroad.

MATAWAN. . . . . Eleva., 35.66 ft.

This bench-mark is a cross cut on south end of stone door-sill of Episcopal church, on Main street.

MONMOUTH BEACH. . . . . . . Eleva., 10.252 ft.

A cross cut on east end of lower stone step of southern flight at entrance, 40 feet from and in front of Episcopal church, near Life Saving Station No. 4.

NAVESINK LIGHT. U. S. C. S. . . Eleva., 202.464 ft.

This bench-mark is a mark on top surface of a heavy granite post near Navesink light-house. The post is deeply imbedded and its top projects about 1½ feet above the surface of the ground. It is 13 meters (42.6 feet) south of the southernmost tower of Navesink Highlands light-house.

NAVESINK LIGHT. U. S. C. S. Primary Mark D. Eleva., 207.579 ft.

This bench-mark is the bottom surface of a square cavity (about 1 inch square) cut on a sloping ledge at southeast corner of base of southernmost light-house tower at Navesink Highlands light.

U. S.
It is marked thus— B. □ M.
1881.

NORTH LONG BRANCH. . . . . Eleva., 7.26 ft.

On a marble monument, 150 yards north of Charles Van Note's blacksmith shop, at east side of Ocean avenue, just north of a low place in the road.

OCEAN BEACH. . . . . . . Eleva., 20.151 ft.

A cross cut on south end of stone door-sill of front entrance of brick school-house, at Ocean Beach.

OCEANPORT. U. S. C. S. . . . . Eleva., 3.499 ft.

This is the bottom surface of a square cavity cut on the south pier of the draw-bridge known as the Oceanport draw-bridge, about 1½ miles north of the Branchport station, New Jersey Central railroad.
It is marked thus— B. □ M.
It is on west side of railroad and some distance below its level.

RED BANK. U. S. C. S. . . . . Eleva., 38.499 ft.

This bench-mark is the bottom surface of a cavity cut in center of top of a marble post set in the ground in the yard of the house of Rev. B. F. Leipner, at Red Bank, N. J. The marble post is over 5 feet in length, and buried so that the top projects about 5 inches above the surface of the ground. The house of Mr. Leipner stands at southwest corner of Monmouth and Pearl streets. The bench-mark is

close to southeast corner of the house. The top of stone bears the following inscription:

U. S.
B. ○ M.
1881.

RED BANK. . . . . Eleva., 43.13 ft.

This bench-mark is a cross cut on northwest corner of lower stone step of west or Monmouth street entrance of M. E. church, on southeast corner of Broad and Monmouth streets.

RED BANK. . . . . Eleva., 45.77 ft.

This bench-mark is a cross cut on south end of front door-sill of First National Bank, on Broad street.

SANDY HOOK. U. S. C. S. Mark A. . Eleva., 11.432 ft.
Mark B. . Eleva., 9.419 ft.

These two bench-marks are cedar posts, 4 feet long and 8 inches in diameter, sunk in the ground, with ends projecting above surface of ground about 4 inches. In the center of top of each post is a copper nail surrounded by 5 other similar nails, in the form of a pentagon. The posts are 12 meters apart, and bear east-northeast from the steamer landing (passenger wharf) and nearly northeast from the tide-house, and distant from it about 500 meters (1,640 feet). They are also 95 meters northwest of the red engine-house of New Jersey Southern railroad, and are placed in the edge of a strip of cedars, where the ground is elevated a few feet above the marsh. The southeasterly one is bench-mark B, and the other one, which is two feet higher, is bench-mark A.

SANDY HOOK. U. S. C. S. . . . Eleva., 19.552 ft.

This bench-mark is a cross on the head of a copper bolt driven into the wall of the main light-house, at Sandy Hook. The main light-house is an octagonal tower, resting upon a circular foundation of unhewn stones. This foundation projects on all sides about 8 inches beyond the base of the tower, so as to form a sloping ledge. The copper bolt is a few inches westward of the northwest angle, and 9¼ inches above the ledge above referred to.

SANDY HOOK. U. S. C. S. . . . Eleva., 15.509 ft.

This bench-mark is the center of the inner edge of the second embrasure from the southwest corner of the fort, at Sandy Hook.

SEABRIGHT. U. S. C. S. Mark IV. . . Eleva., 9.283 ft.

This bench-mark is the bottom surface of a square cavity (1 inch square) cut on the north wing wall of the west abutment of bridge over the South Shrewsbury river, at Seabright. The top of the wing wall forms a series of steps, and the bench-mark is cut on the first step below the top.

It is marked thus— B. ▭ M.

SEA GIRT. . . . . Eleva., 19.47 ft.

A point of an arrow-head cut in the stone under second pillar of the piazza at northeast corner of the northern of the two four-story buildings of the Beach House, Sea Girt.

SPRING LAKE. . . . . Eleva., 18.351 ft.

Elevation of underground mark, 13.978 ft.

This monument (No. 4) is located on the lot of Life Saving Station No. 8, Spring Lake, on the east side of Ocean avenue, between Ocean Beach and Spring Lake. At the time of setting the monument the station building was so located that the northerly edge of the roof was about on the line of the lot, but the front was about 25 feet on the avenue. The monument was set 27.6 feet back from the west end of station, and 5 feet south of its south side.

It may also be located as follows: Beginning at the point where the line of south curb of St. Clair avenue intersects the center line of Ocean avenue, and running thence N. 22′ 15″ E., 973 feet along center line of said avenue to a point in line with south side of station; thence along the station 52.6 feet; thence at right angles to station, 5 feet to the monument.

The monument was set with its top level with the surface of ground, which was a little higher than the surrounding surface.

TENNENT. . . . . Eleva., 89.91 ft.

This bench-mark is on a large oak tree at the east end of the Freehold and Jamesburg railroad station.

WEST END. . . . . Eleva., 12.256 ft.

Elevation of underground mark, 7.574 ft.

This monument (No. 3) is erected according to the description already given (page 14, report 1885), but its top is placed even with the surface of ground. It is located on the lot of Life Saving Station No. 5, West End, and is placed at a distance of 10 feet, measured perpendicularly from the middle of the west end of station building. The line of face of north abutment of the Ocean avenue bridge, over Lake Takanassee, passes 6 feet to south of center of monument, and the magnetic bearing of this line is S. 75° 30′ E.

The monument is 224½ feet back from the line of Ocean avenue.

Morris County.

BOONTON. . . . . Eleva., 412.94 ft.

A cross cut on the east corner of the coping-stone, level with the railroad at the north corner of the Delaware, Lackawanna and Western railroad bridge over the Rockaway river.

BOONTON. . . . . Eleva., 398.76 ft.

A cross cut on the upper granite step at the east end of the north wall of the Morris canal lock, 300 yards northeast of Main street. This is also a canal bench-mark.

DENVILLE. . . . . Eleva., 512.86 ft.

A cross cut on the northeast corner of a stone on the top of the south wall of the Morris canal lock No. 7, right at the end of the gate, when open.

DENVILLE. . . . . Eleva., 508.77 ft.

This bench-mark is on the north abutment of the Morris and Essex railroad bridge over Den brook. The point is on the outside corner of the third step from the top of the east end of the abutment.

DOVER. . . . . Eleva., 575.15 ft.

A cross cut on the southwest corner of the west parapet of the bridge over the Rockaway river at Sussex street.

DOVER. . . . . Eleva., 572.99 ft.

A cross cut on the water-table at the southeast corner of George Richards' brick building at the northwest corner of Blackwell and Sussex streets.

LAKE HOPATCONG. . . . . . . Eleva., 925.67 ft.

A cross cut on the east corner of the north end of the west wall of the race of the Morris canal lock at the outlet of the lake. This is also a canal bench-mark.

LINCOLN PARK. . . . . Eleva., 182.60 ft.

A cross cut on the southwest corner of the stone forming the upper step at the east end of the north wall of the Morris canal lock No. 12, east.

MONTVILLE. . . . . Eleva., 239.57 ft.

A cross cut on the summit of a very large rounded boulder imbedded in the tow-path at the edge of the canal, 200 yards east of the lower plane.

MONTVILLE. . . . . Eleva., 387.87 ft.

A cross cut on a projecting stone on the top of the wall at the south side of the square well into which the water falls at the top of the upper plane of the Morrris canal.

MORRISTOWN. . . . . Eleva., 403.79 ft.

A cross cut on the east end of the sill, close by the west side, of the most easterly of two wooden pillars at the entrance of the Morris county court-house.

MORRISTOWN. . . . . Eleva., 378.09 ft.

A cross cut on the south end of the sill of the entrance to the First National Bank.

MORRISTOWN. . . . . Eleva., 376.89 ft.

This bench-mark is on the flat surface, directly under the carved stone cannon at the west corner of the base of the soldiers' monument in the city park.

MOUNT TABOR. . . . . Eleva., 502.06 ft.

A cross cut on the northwest corner of the coping of the wall over the north end of a culvert, under the Morris and Essex railroad, for carrying off the overflow of a pond about one mile east of Mount Tabor.

PORT MORRIS. . . . . Eleva., 916.13 ft.

This bench-mark is on the southeast corner of the pier at the southeast corner of an iron bridge over the race at the top of the Morris canal plane.

PORT ORAM. . . . . Eleva., 665.61 ft.

A cross on the northeast corner of the cast-iron bed-plate at the northeast corner of the bridge by which the High Bridge branch of the Central Railroad of New Jersey crosses the Delaware, Lackawanna and Western railroad.

685.25 ft.

PORT ORAM. . . . . Eleva., [redacted]

A cross cut on the southwest corner of the east abutment of the Delaware, Lackawanna and Western railroad bridge over the Rockaway river, one and one-half miles west of Port Oram.

PORT ORAM. . . . . Eleva., 612.60 ft.

A cross on the outside corner of the upper step at the north end of the western abutment of the Delaware, Lackawanna and Western railroad bridge over the Rockaway river, three-quarters mile southeast of Port Oram.

POWERVILLE. . . . . Eleva., 494.92 ft.

This bench-mark is on the north corner of the coping at the northwest end of the southwest wall of the Morris canal guard lock. This is also the canal bench-mark No. 46.

ROCKAWAY. . . . . Eleva., 523.18 ft.

This bench-mark is on the northeast corner of the flange of the cast-iron foot-plate at the northeast corner of the iron bridge over the Morris canal, at the foot of the plane.

ROCKAWAY. . . . . Eleva., 524.16 ft.

A cross cut on the outside corner, on top and at the west end of the south abutment of the Hibernia Mine railroad bridge.

SHIPPENPORT. . . . . Eleva., 875.84 ft.

A cross cut on the outside corner of the highest of a series of steps at the south end of the west abutment of the Delaware, Lackawanna and Western railroad bridge over the Morris canal.

WHITEHALL. . . . . Eleva., 183.51 ft.

On a point indicated by an arrow on top of the lowest course of masonry at the southwest corner of the east abutment of the road bridge under the Delaware, Lackawanna and Western railroad, at the foot of the Morris canal plane No. 10, east.

Ocean County.

BARNEGAT. . . . . Eleva., 35.76 ft.

A cross cut in east end of lowest flagstone step on south side of the basement front door of Baptist church.

BARNEGAT CITY. . . . . . Eleva., 13.28 ft.

A cross cut on the center of the rib on the iron sill of the inner door of Barnegat light-house.

BARNEGAT CITY. . . . . . Eleva., 13.14 ft.

This bench-mark is on a square shelf cut on the top of the stone water-table under the center of the windows on the north side of Barnegat light-house.

MANTOLOKING. . . . . Eleva., 4.146 ft.

Elevation of underground mark, 0.780 ft.

This monument (No. 5) is located on the lot of Life Saving Station No. 11, Mantoloking, on the beach about half a mile south of the railroad station. It is placed north 67° east, 2 feet from the southwest corner of the lot. The location with reference to property line surveys is as follows: Beginning at a corner on the salt meadows, which is south 14° west, 281 feet from the point of meadows at east

side of mouth of a small creek, and north 85° west, 150 feet from head of same creek; running thence north 86° east, 550 feet to the intersection of this line with the produced west line of above-mentioned lot; thence north 22° east, 33½ feet to southwest corner of lot; thence north 67° east, 2 feet to the monument.

[This monument is set 3½ feet deep, and rests on the old meadow which underlies the beach at this place. The turf of the meadow was not disturbed, but an area of cement was spread right upon it. It can scarcely be entirely depended upon, but shrinkage of the new cement and settlement of stone had only amounted to .014 foot one month after setting.]

TOMS RIVER. . . . . Eleva., 30.38 ft.

Elevation of underground mark, 25.40 ft.

This monument (No. 6) is placed in the southwest corner of the Ocean county court-yard, 3 feet back from the iron front fence and 3 feet east of west line of lot. Measured parallel with Washington street, it is 28.75 feet west of the west line of Allen street produced, 72.3 feet west of center line of court-house, and 145 feet west of southern marble true meridian monument which stands in southeast corner of the yard. The monument is also distant 69.6 feet southwesterly from the southwest corner of court-house.

TOMS RIVER. . . . . Eleva., 32.67 ft.

A cross cut on east end of stone door-sill of main entrance of Ocean county court-house, Toms River.

WARETOWN. . . . . Eleva., 12.664 ft.

Elevation of underground mark, 8.429 ft.

This monument (No. 7) is located at the cross-roads at the Hopkins House, where the center line of the road from Waretown station, New Jersey Southern railroad, to the shore of Barnegat bay, intersects the easterly fence line of the main shore road. It is 86.2 feet from southwest corner of hotel, 17.7 feet from northeast stone pier under porch of store, and 20.7 feet from center of willow tree standing just to southwest of it. Measuring along the produced first course of the road running by a small graveyard to the bay, the distances are, to edge of upland, 1,540 feet, to ordinary high-water mark, 2,850 feet. The top of monument was placed just below the surface of the road.

WARETOWN. . . . . Eleva., 20.72 ft.

On center of southwest side of large granite (Falkinsburg) monument, on top of small, flat projection of the top base-stone directly under the polished inscription-face, upon the bottom of which is cut, "Died May 10, 1855." The monument is in the Waretown cemetery, east of main shore road.

WHITINGS. . . . . Eleva., 173.46 ft.

Elevation of underground mark, 170.583 ft.

This monument (No. 16) is located at the cross-roads in Whitings, where the road from New Egypt to Toms River crosses the road running along the west side of the New Jersey Southern railroad from Woodmansie to Manchester. It is set in the center line of the former road, and in line with the trees planted along the west side of the latter road, between the sidewalk and wagon track. It is 41.5 feet southwest of the southwest corner of Mr. Wright's store; 11 feet from the west line of the street running nearly north and south; 88 feet to center of the main track of the New Jersey Southern railroad; 21 feet to center of nearest maple tree of the row on the north; 45.4 feet to center of the next; 21.7 feet to center of nearest maple tree of the row on the south, and 46.9 feet to the next.

The top of this monument is below the surface.

WHITINGS. . . . . Eleva., 172.53 ft.

On granite monument marking northwest corner of roads. It is 7 yards distant from southeast corner of large hotel.

Passaic County.

CENTERVILLE. . . . . Eleva., 179.50 ft.

This bench-mark is on a small cut in a projecting stone, 4.6 feet above the ground, at the west end of the north abutment of the road bridge over the Morris canal, 1 mile southwest of Centerville. The point is indicated by an arrow-head.

HAWTHORNE. . . . . Eleva., 42.83 ft.

A cross cut on the outside corner of the east end of the coping of the north abutment of the New York, Lake Erie and Western railroad bridge over the Passaic river.

LITTLE FALLS. . . . . Eleva., 194.90 ft.

A cross cut on the northeast corner of the stone sill of the main front door of the Dutch Reformed church.

LITTLE FALLS. . . . . Eleva., 174.67 ft.

A cross cut on the stone coping at the end of the iron railing on the west side of the Passaic river, Morris canal aqueduct.

MOUNTAIN VIEW. . . . . . . Eleva., 175.74 ft.

A cross cut on the north corner of the west end of the coping of the circular wall at the north end of the west abutment of the aqueduct by which the Morris canal crosses the Pompton river.

PATERSON. . . . . Eleva., 108.51 ft.

A cross cut on the south end of the sill of the Main street entrance of St. Boniface Church, at the southeast corner of Main and Slater streets.

PATERSON. . . . . Eleva., 100.37 ft.

This bench-mark is a cross cut on the corner-stone at the northeast corner of the Passaic county court-house.

PATERSON. . . . . Eleva., 89.92 ft.

A cross cut on the east end of the sill of the main front door of the Market Street M. E. Church.

PATERSON. . . . . Eleva., 95.94 ft.

A cross cut on the north end of the sill of the main entrance of the First Presbyterian Church.

PATERSON. . . . . Eleva., 175.96 ft.

A cross cut on a projection in the lowest corner-stone at the southeast end of the west abutment of the Delaware, Lackawanna and Western railroad bridge over the Morris canal, between Little Falls and Paterson.

RICHFIELD. . . . . Eleva., 182.56 ft.

A cross cut on the north end of the east abutment of the bridge over the Morris canal. The point is at the end of the timber on which the bridge rests.

Salem County.

DARETOWN. . . . . Eleva., 127.80 ft.

This bench-mark is a cross cut on north end of stone door-sill of front entrance of Daretown Presbyterian church.

ELMER. . . . . Eleva., 116.83 ft.

This bench-mark is a cross cut on west end of marble door-sill of front entrance of brick public school-house.

RIDDLETON JUNCTION. . . . . . Eleva., 41.25 ft.

This bench-mark is on the frog (1 foot from its point), at the junction of the railroad from Swedesboro with the railroad from Elmer to Salem.

SALEM. . . . . Eleva., 14.67 ft.

This bench-mark is a cross cut on south end of granite door-sill of front entrance of Episcopal church, on Market street.

SALEM. . . . . Eleva., 15.88 ft.

This bench-mark is a cross cut at the foot of fluted column, on south side of entrance to surrogate's and clerk's office.

WOODSTOWN. . . . . Eleva., 47.67 ft.

This bench-mark is a cross cut on south end of marble door-sill of front entrance of brick Baptist church, on Main street.

WOODSTOWN. . . . . Eleva., 46.12 ft.

This bench-mark is a cross cut on north end of lowest stone step of front entrance of Woodstown Hotel.

WOODSTOWN. . . . . Eleva., 58.74 ft.

This bench-mark is a cross cut on southwest end of marble door-sill of brick National Bank of Woodstown.

Somerset County.

BOUND BROOK. U. S. C. S. . . . Eleva., 32.483 ft.

This bench-mark is the bottom surface of a square cavity cut on top of stone abutment (northeast corner) of New Jersey Central railroad bridge, about one-fourth mile east of Bound Brook station.

It is marked thus— B. ▭ M.

BOUND BROOK. U. S. C. S. . . . Eleva., 35.744 ft.

This is the bottom of a square cavity (1 inch square by one-third inch deep), cut on top stone of west end of north abutment of road bridge over Raritan river, at Bound Brook.

It is marked thus— B. ▭ M.
XIII.
1881.

EAST MILLSTONE. . . . . . . Eleva., 45.48 ft.

A triangle on the southwest corner of a stone supporting south gate-post at entrance to N. S. Wilson's brick residence, south of Thatchler's drug store, at easterly corner of Market street and Railroad avenue.

GRIGGSTOWN. . . . . Eleva., 44.07 ft.

On summit of stone, indicated by an arrow, standing at east corner of Edgar's mill, on west side of canal, at Griggstown.

GRIGGSTOWN. . . . . Eleva., 50.53 ft.

A triangle on the coping of west lock wall under east edge of bridge, at Delaware and Raritan canal lock, half a mile south of Griggstown.

NORTH BRANCH STATION. U. S. C. S. . Eleva., 84.880 ft.

This bench-mark is the bottom surface of a square cavity cut near the top of the southwest corner of New Jersey Central railroad bridge over the north branch of Raritan river, a short distance east of the North Branch railroad station.

It is marked thus— B. ▭ M.
XV.

ROCKY HILL. . . . . Eleva., 43.91 ft.

Center of triangle cut on the east end of stone door-sill at entrance of old stone grist-mill beside race, 50 rods west of railroad station.

SOMERVILLE. U. S. C. S. . . . . . Eleva., 81.800 ft.

This is the bottom surface of a circular cavity in the metal on top of the southern "true meridian" granite post, in grounds of the court-house, Somerville.

SOMERVILLE. U. S. C. S. . . . . . Eleva., 91.280 ft.

This bench-mark is, as usual, the bottom surface of a square cavity cut in stone, at the base of the easternmost pillar of the front of the court-house, Somerville.

It is marked thus—

G.
B. ▭ M.
U. S. C. & G. S.
1881.

SOMERVILLE. . . . . Eleva., 46.28 ft.

This bench-mark is indicated by a cross cut inside of a triangle on the east edge of the west abutment under the center of the railroad track on the truss bridge carrying the South Branch railroad over the Raritan river.

WESTON. . . . . Eleva., 42.97 ft.

A triangle cut on the coping of Delaware and Raritan canal lock and six feet north of east edge of lock bridge.

Sussex County.

ANDOVER. . . . . Eleva., 638.05 ft.

This bench-mark is on the large gneiss rock on the bank, on the east side of the Sussex railroad, 145 yards north of the station and 9 yards north of the cattle-pens.

ANDOVER. . . . . Eleva., 584.80 ft.

This bench-mark is on the frog on the east rail of the Sussex railroad and on the north rail of the Lehigh and Hudson River railroad, at their grade crossing, just north of Andover.

BRANCHVILLE. . . . . Eleva., 526.77 ft.

A cross cut on the center of the large stone (one foot from its west edge) in the top course on the west end of the north abutment of the Sussex railroad bridge over Dry brook, 25 yards south of crossing, over the railroad, of the road to Augusta and southeast of the entrance of the road to Swartswood. The bench is not on the single stone which is upon the top of the wall.

BRANCHVILLE. . . . . Eleva., 579.69 ft.

A cross cut on the southeast corner of the first step below the wide surface stone at the entrance to the cellar on the front of the west corner of Stivers Hall, on the north side of the road forks.

BRANCHVILLE JUNCTION. . . . . . Eleva., 560.73 ft.

This bench-mark is on the east rail of the Sussex railroad (Branchville branch) and the north rail of the New York, Susquehanna and Western railroad, at their crossing.

CARPENTER'S POINT. . . . . . . Eleva., 452.30 ft.

This bench-mark is the top of State line monument, at the road which runs from Port Jervis to Montague.

CARPENTER'S POINT. . . . . . . Eleva., 421.36 ft.

This bench-mark is the top of the State line monument, on the east shore of the Neversink river.

CARPENTER'S POINT. . . . . . . Eleva., 414.99 ft.

This bench-mark is on the Tri-State monument, at the meeting of the boundary lines of New Jersey, New York and Pennsylvania, on the extreme point at the forks of the Delaware and Neversink rivers.

CARPENTER'S POINT. . . . . . . Eleva., 480.93 ft.

This bench-mark is on the State line monument on the east side of the turnpike to Deckertown, at the Two States Hotel.

COLEVILLE. . . . . Eleva., 791.95 ft.

A cross cut on the east corner of the most easterly of three large flagstones under the porch of the lower hotel.

COLEVILLE. . . . . Eleva., 908.30 ft.

A cross cut on the large boulder at the entrance of the road to Sand pond, about 1 mile northwest of Coleville.

CULVER'S GAP. . . . . Eleva., 915.35 ft.

This bench-mark is on the summit of a conglomerate boulder on the northeast corner of the roads meeting in the gap.

DECKERTOWN. . . . . Eleva., 440.92 ft.

A cross on the south end of the stone door-sill of the brick store building on the northwest corner of the streets on the south corner of the open triangle opposite Decamp's hotel.

DECKERTOWN. . . . . Eleva., 441.67 ft.

A cross cut on the stone water-table on the southeast corner of the brick building (with the north end stone and corners trimmed with the same) used as a furniture store. It is 45 yards north of the Union House.

FRANKLIN FURNACE. . . . . . . Eleva., 535.45 ft.

This bench-mark is the frog at the junction of the Sussex railroad with the New York, Susquehanna and Western railroad.

FRANKLIN FURNACE. . . . . . . Eleva., 560.13 ft.

This bench-mark is on the stone water-table at the southwest corner (front corner towards the new furnace) of the company's brick store and office.

HAINESVILLE. . . . . Eleva., 639.29 ft.

A cross cut on the top of an imbedded rock, with rounded summit, on the east side of the road, 40 yards north of the corner of roads at which the church and school-house are situated.

HAINESVILLE. . . . . Eleva., 748.62 ft.

A cross cut on a white rock on the southwest corner of the junction of the roads, about 2 miles south of Montague, and 1⅓ miles north of Hainesville.

HIGH POINT. . . . . Eleva., 1800.21 ft.

This bench-mark is the highest point of the bed-rock on the summit of the mountain.

HIGH POINT. . . . . Eleva., 1804.30 ft.

This bench-mark is a cross cut on the top of a boulder on the summit of the mountain. This is the highest point in New Jersey.

LAFAYETTE. . . . . Eleva., 549.94 ft.

This bench-mark is on the summit of a limestone boulder, indicated by an arrow, at the east corner of the main cross-roads in the village.

LAFAYETTE. . . . . Eleva., 512.60 ft.

A cross cut on the southeast corner of the limestone on top of the south abutment on the east side of the Sussex railroad track where it crosses above the wagon road, just east of the cross-roads, about 1 mile north of the village.

MONTAGUE. . . . . Eleva., 520.82 ft.

A cross cut on the rough stone water-table near the bar-room door of the Brick House hotel.

NEWTON. . . . . Eleva., 601.24 ft.

A cross cut on the stone sill of the most northerly of three doors (baggage-room) in the east side of the Newton station of the Sussex railroad.

NEWTON. . . . . Eleva., 649.63 ft.

A cross cut on the east end of the stone sill of the north door to the clerk's and surrogate's offices.

NEWTON. . . . . Eleva., 648.68 ft.

A cross cut on the east end of the outside of the stone door-sill at the entrance of the Sussex county court-house.

NEWTON. . . . . Eleva., 678.46 ft.

A cross cut on the east end of the stone door-sill at the corner of the jamb of the central entrance of the Presbyterian church.

STANHOPE. . . . . Eleva., 871.13 ft.

A cross cut on the northwest corner of the cap-stone of turret supporting the cable at the southeast corner of the bridge over the Morris canal, at the outlet of the reservoir.

STANHOPE. . . . . Eleva., 864.15 ft.

A cross cut on the outside corner of the coping at the west end of the north wall of the Morris canal lock, at the outlet of the reservoir. This is also a canal bench-mark.

TUTTLE'S CORNER. . . . . . . Eleva., 756.87 ft.

This bench-mark is on the summit of a large boulder on the northwest corner of the roads meeting about three-quarters mile south of Tuttle's Corner.

WATERLOO. . . . . Eleva., 655.44 ft.

A cross cut on the southwest corner of the north abutment of the Sussex railroad bridge over the Musconetcong river, at the head of Waterloo pond.

WHITEHALL. . . . . Eleva., 777.05 ft.

This bench-mark is on the summit of the most westerly of two spurs of the gneiss rock at the northeast corner of the road from Stanhope to Andover and a road running northeast, at the north end of the Cranberry reservoir.

WHITEHALL. . . . . Eleva., 705.58 ft.

This bench-mark is on a small rounded summit, marked by an arrow, on top of the coping-stone, 2 inches back of the face of the wall, and directly over the center of the keystone of the east side of the stone arch carrying the Sussex railroad over the wagon road, just north of Whitehall and about 1 mile south of Andover.

Union County.

ELIZABETH. . . . . Eleva., 36.44 ft.

A cross cut on the south end of the stone sill of the main front door of the First Presbyterian Church.

ELIZABETH. . . . . Eleva., 32.71 ft.

A cross cut on the south end of the stone sill of the main front door of the Union county court-house.

ELIZABETH. . . . . Eleva., 38.45 ft.

This bench-mark is on the pier supporting the North Elizabeth railroad station, situated between the east-bound freight and passenger tracks. The point is a cross at the north corner, on a projecting tier of masonry, about $1\frac{1}{2}$ feet from the ground. It is also a railroad bench-mark, and is marked in red paint thus— B. M. ○

LINDEN. . . . . Eleva., 25.80 ft.

This bench-mark is a cross on the southeast corner of the west wall of the Pennsylvania railroad bridge over Morse's creek, a quarter of a mile southwest of the station.

LINDEN. . . . . Eleva., 19.70 ft.

This bench-mark is on the north abutment of the Pennsylvania railroad bridge over the north branch of Morse's creek, about a mile and a half north of Linden. The point is marked by a cross on the southwest corner of the stone on which the northwest corner of the bridge rests.

RAHWAY. . . . . Eleva., 18.81 ft.

A cross cut on the stone foundation at the northwest corner of the Second Presbyterian Church. A niche in the buttress at this corner exposes the foundation for an area about 6 inches square; on this is the cross.

RAHWAY. . . . . Eleva., 20.47 ft.

This bench-mark is a cross cut on the northwest corner of the stone on the south abutment of the Perth Amboy branch railroad bridge over the south branch of the Rahway river. The point is about 1 foot below the level of the track and 7 feet west of the center of the south-bound track.

Warren County.

BELVIDERE. . . . . Eleva., 264.09 ft.

A cross cut on the east end of the door-sill of the stone water-tank at the junction of the Lehigh and Hudson River railroad with the Belvidere division of the Pennsylvania railroad.

BELVIDERE. . . . . Eleva., 285.01 ft.

This bench-mark is on the west end of the stone door-sill of the surrogate's office. It is the most westerly of the three doors in the front of the Warren county court-house.

BELVIDERE. . . . . Eleva., 288.88 ft.

A cross cut on the northeast corner of the stone sill of the middle door of the First Presbyterian Church, which stands on the west side of the city park.

BROADWAY. . . . . Eleva., 434.73 ft.

This bench-mark is on the southwest corner of a square-dressed stone, 2½ feet from the end of the wooden sill lying on it, at the south side of the floodgate of the Morris canal, just south of the road from Broadway to Montana.

BUTTZVILLE. . . . . Eleva., 383.00 ft.

This bench-mark is on the joint of the south rail of the Lehigh and Hudson River railroad, at the north end of the stone wagon bridge, 225 yards east of the station.

BUTTZVILLE. . . . . Eleva., 423.32 ft.

A cross cut on the outer edge of the coping-stone on the south side of the Delaware, Lackawanna and Western railroad track, and directly over the keystone of the center arch of the stone bridge over the Pequest river and the Lehigh and Hudson River railroad, just east of Buttzville.

BUTTZVILLE. . . . . Eleva., 364.44 ft.

A cross cut on the top of the main wall of the west abutment, at the angle of the wall on the north side of the track where the Lehigh and Hudson River railroad crosses over the wagon road, about one mile west of the station.

EASTON, PA. U. S. C. S. . . . . Eleva., 214.401 ft.

This bench-mark is the bottom surface of a square cavity cut on top of a pier (north side of New Jersey Central railroad track) of bridge across the Lehigh river at Easton. It is on the pier at the west end of wide part of bridge.

U. S.
It is marked thus— B. ▭ M.
XIX.

EASTON, PA. U. S. C. S. . . . . Eleva., 357.186 ft.

This is the bottom of a square cavity cut in foundation stone at west corner of the jail at Easton. The front of the jail is built of red sandstone and the foundation of blue limestone.

EASTON, PA. U. S. C. S. . . . . Eleva., 363.488 ft.

This bench-mark is the bottom surface of a square cavity cut on the sill of a blind window on east side of Easton court-house. This side of the court-house has two blind windows, but the one used is the one nearest to the front of the building.

U. S. C. & G. S.
H.
It is marked thus— B. ▭ M.
1881.

HACKETTSTOWN. . . . . . . Eleva., 594.81 ft.

This bench-mark is on the sandstone water-table at the northwest side, close to the brickwork, of the Centenary Collegiate Institute.

HACKETTSTOWN. . . . . . . Eleva., 573.18 ft.

An arrow-head cut on the corner toward the road, of the top of the northwest wing wall of the Delaware, Lackawanna and Western railroad bridge over the turnpike, just south of Warren furnace.

HUTCHINSON'S STATION. . . . . . Eleva., 239.44 ft.

This bench-mark is the bottom of a slot cut in the north end of a long yellow stone at the north end of the main wall of the stone bridge over the wagon road.

LOPATCONG. . . . . Eleva., 218.95 ft.

A cross cut on the summit of the most westerly stone in the coping of the north wall of the upper Morris canal lock.

MARTIN'S CREEK STATION. . . . Eleva., 226.85 ft.

A cross cut on a red stone on the south end of the wall on the east side of the railroad track, and the south side of the wagon road, at the crossing near the north end of the station.

NEW VILLAGE. . . . . Eleva., 435.36 ft.

A cross cut on the rounded summit of the coping-stone on the west side of the south wall of the Morris canal lock, west of the village. The summit is 1.5 feet from the end of the wall, and about 3 yards from the tail-gates.

OXFORD FURNACE. . . . . . . Eleva., 479.77 ft.

A cross cut on the east end of the stone sill of the front door of the Oxford Iron and Nail Co.'s brick store, on the north corner of streets, just south of the railroad station.

OXFORD FURNACE. . . . . . . Eleva., 501.84 ft.

A cross cut on the east end of the stone door-sill of the front door of the Second Presbyterian Church.

PHILLIPSBURG. . . . . Eleva., 195.56 ft.

A cross cut on the northwest corner of the stone water-table under the column on the east side of the north entrance of the Pennsylvania railroad station, at the east end of the covered bridge over the Delaware river.

NEAR PHILLIPSBURG. U. S. C. S. . . Eleva., 262.986 ft.

This bench-mark is the bottom surface (center) of a square cavity cut in coping-stone at east end of north parapet of stone bridge (New Jersey Central railroad) over the Morris canal, about 1½ miles east of Phillipsburg.

It is marked thus— B. □ M.
1881.

PORT COLDEN. . . . . Eleva., 570.16 ft.

This bench-mark is on the southeast corner of the masonry, at the gates of the flume, at the head of plane No. 6, west, Morris canal.

PORT MURRAY. . . . . Eleva., 630.99 ft.

This bench-mark is on the north corner of masonry of the gates at the head of the flume of the Morris canal plane No. 5, west.

PORT WARREN. . . . . Eleva., 334.39 ft.

A cross cut on the southeast corner of the bottom step of a series forming the end of the foundation wall at the southeast corner of the wheel-house of the Morris canal plane No. 9, west.

ROXBURY STATION. . . . . . . Eleva., 245.47 ft.

This bench-mark is on a cross on the northeast corner of the south abutment of the bridge over the wagon road at the north side of the Pennsylvania railroad station.

SAXTON FALLS. . . . . Eleva., 642.86 ft.

A cross cut on the corner of a stone in which the west tail-gate is anchored, close to the south side of the quoin, Morris canal, lock No. 4.

SAXTON FALLS. . . . . Eleva., 637.69 ft.

A cross on the coping of the west lock wall, just back of the middle of a groove for temporary repair dam, just above the chamber for the head-gate of the Morris canal guard lock.

STEWARTSVILLE. . . . . . . Eleva., 405.83 ft.

A cross cut on the foundation at the east corner of the wheel-house at the Morris canal plane No. 8, west.

STEWARTSVILLE. . . . . . . Eleva., 374.25 ft.

A cross cut on the northwest corner of the square-dressed stone on which the bed-plate of the truss rests, at the north end of the east abutment of the Morris and Essex railroad bridge over the Morris canal, east of the station. This stone is on a level with the bottom of the sills of the wooden bridge, and the corner is 12.7 feet from the sill.

WASHINGTON. . . . . Eleva., 462.01 ft.

This bench-mark is on the corner of a stone under the iron column at the northeast corner of the Beatty building, at the southwest corner of Belvidere and Washington avenues.

WASHINGTON. . . . . Eleva., 485.52 ft.

This bench-mark is on the west end of the brownstone door-sill, close to the corner of the brickwork, of the main (middle) entrance of the Presbyterian church.

WASHINGTON. . . . . Eleva., 467.54 ft.

This bench-mark is on the stone water-table of the Windsor Hotel, a brick building facing on Washington avenue. The point is on the rear corner of a wing, with three windows, extending back from the main building on Belvidere avenue.

WASHINGTON. . . . . Eleva., 508.08 ft.

This bench-mark is on the northwest corner of the north end, on top of the wall supporting the wooden flume at the top of Morris canal plane No. 7, west. The point is also a canal bench-mark, and is marked with red paint.

WASHINGTON. . . . . Eleva., 463.05 ft.

A cross on the southeast corner of the highest of three stone steps at the entrance of the First National Bank, on the northwest corner of Belvidere and Washington avenues.

ELEVATIONS OF PROMINENT POINTS REFERRED TO MEAN SEA LEVEL.

The following list of elevations includes the latest and best determinations. In case of difference between these elevations and those shown on the map, these are to be preferred, as they have been adjusted to the Sandy Hook datum. These elevations are not so carefully determined as those in the list of bench-marks preceding, and those should always be used when great accuracy is required, but the following are sufficiently accurate for all ordinary purposes. At the railroad stations it has been customary to note the elevation at the rail joint nearest the center of the station. At railroad crossings, a joint was usually taken also.

This list of elevations will be found convenient for reference, and will be especially useful to those who may not have access to the topographical atlas. It gives the highest point in each county and some well-known point in each town and village. All elevations are in feet.

Atlantic County.

Atsion. Rail at crossing just west of station	47.4
Bakersville. Nail in door-sill of Central M. E. Church	27.0
Bargaintown. Stone at northeast corner of west abutment of bridge over pond,	8.8
Buena Vista. East rail at station	104.7
Cedar Lake. West rail at crossing by station	84.0
Da Costa. North rail at crossing by station, C. & A. R. R	84.3
Doughty's station. North rail, C. & A. R. R	29.9
Downstown. Bench-mark on button-ball tree, just east of store	115.3
English Creek. Bench-mark on willow, in front of store	9.6
English Creek station. South rail	60.4
Estelville. Bench-mark on oak, northwest corner, by M. E. church	23.6
Frankfort Avenue station. North rail at crossing, C. & A. R. R	60.1
Germania station. North rail at crossing, C. & A. R. R	59.4
Highest point in county, near Hammonton Coast Survey station, one mile northwest of Hammonton	152.
Landisville. North rail at station	113.1
Landisville. Rail at crossing of N. J. S. R. R. and W. J. R. R	120.5
Leeds' Point. Bench-mark on wild cherry at southeast corner, just west of hotel,	54.0
Mays Landing pond	13.
Murphy's station. North rail at crossing, C. & A. R. R	114.5
Parkdale station. North rail at crossing	59.8
Pleasantville. Rail of P. & A. C. R. R. at shore road crossing	25.2
Pomona station. North rail at crossing, C. & A. R. R	66.2
Port Republic Projecting stone at southwest wing wall of draw-bridge	7.1
Richland. Rail at crossing northwest of station	99.4
Richland Coast Survey station	109.
Smith's Landing. Bench-mark on large ailanthus tree in front of house, just south of corner	34.1
Weekstown. East end of wooden door-sill of school-house	20.5
Weymouth. Bench-mark on button-ball tree at road forks, southwest of paper mill	44.4
Weymouth pond	37.

Bergen County.

Alpine. Bench-mark on oak, northeast corner of cross-roads on top of Palisades mountain	441.2
Arcola. Cross on stone door-step of store	49.7
Bergen Fields. Rail at crossing north of station	69.5
Camp Gaw. North rail at station	380.8
Cherry Hill. Rail at crossing by station	8.3
Corona. Rail at station	6.8
Cresskill. Rail at station	40.9
Etna. Rail at station	46.0
Fort Lee. Lowest step, main entrance of Madonna R. C. Church	314.2
Franklin lake	414.

Bergen County—Continued.

Hackensack river at State line	45.
Highest point in county, Ramapo mountain, near State line	1171.
Hillsdale. Frog at station	57.3
Kingsland. Rail at crossing near station	28.2
Leonia. West rail at crossing near station	5.8
Lodi. Rail at Main street crossing	24.8
Maywood. North rail at crossing	68.8
Midland Park. Rail at station	202.9
Montvale. Bench-mark on oak, opposite the Grove House	180.5
Neuvy. Rail at station	38.1
New Milford. Rail at crossing by station	16.8
Norwood. Rail at station	36.0
Oakland. South rail at station	274.3
Oradell. Rail at station	21.0
Palisades mountain. Summit of	545.
Park Ridge. West rail at station	150.4
Pascack. West rail at crossing south of station	106.3
Ramapo river. At Oakland	207.
Ramapo river. At Suffern	272.
Ramapo mountain	1171.
River Edge. Rail at crossing by station	16.2
River Vale. South edge of mill-stone in south door of school-house	70.1
Rochelle Park. South rail at crossing by station	46.1
Rotten pond, in Ramapo mountain	534.
Rutherford. Top of monument near flag-staff, in grass plat behind station	47.3
Saddle River. West corner of sill, main door of stone church	269.1
Schraalenburg. Rail at crossing north of station	16.8
State line monuments.	
1st	200.3
2d	29.4
3d	109.0
4th	108.4
5th	78.8
6th	160.
7th	272.2
8th	227.6
9th	393.6
10th	372.9
11th	302.4
12th	417.9
13th	573.3
14th	517.3
15th	287.4
16th	608.5
17th	765.6

Bergen County—Continued.

Westwood. Southwest corner of large stone slab at entrance of Van Emburg & Bogert's store 76.4
Woodridge. Rail at crossing by station........ 10.7
Wortendyke Sill of left entrance to silk mill........ 258.5
Wyckoff. Northeast corner of door-sill of Reformed church 356.2

Burlington County.

Apple-Pie hill .... 209.
Arney's Mount. Highest point in county 230
Batsto Bench-mark on large buttonwood, opposite mill........ 11.1
Bear Swamp hill........ 165
Beverly. South rail at crossing west of station........ 30.1
Brown's Mills station. North rail at crossing........ 71.3
Buddtown. Ring-bolt, center of east arch of iron bridge over Stop-the-Jade run 48.0
Bustleton. Bench-mark on oak at corner by church........ 83.5
Chatsworth. North rail at crossing by station 91.1
Columbus. A cross cut on curb opposite hotel........ 83.2
Cookstown. Bench-mark on maple diagonally opposite hotel........ 83.6
Crosswicks. Step at entrance to basement of Episcopal church........ 80.1
Crowleytown On red sandstone under northwest corner of school-house........ 13.3
East Moorestown station. North rail at crossing. 70.1
Edgewater Park. North rail at crossing east of station........ 30.1
Evesboro. Bench-mark on maple at northwest corner of cross-roads........ 94.3
Four-Mile hill........ 141.
Georgetown. Bench-mark on maple at cross-roads........ 91 9
Green Bank. Bench-mark on rock at forks of roads just south of blacksmith shop........ 25 6
Hainesport. Bench-mark on maple north of railroad and west of road, near station........ 30.9
Hanover station. North rail at crossing........ 92.9
Harris station. South rail at crossing, 300 yards east of........ 98.3
Harrisia. Top of pipe used as guard, east corner of paper mill........ 18.6
Hartford. Bench-mark on cherry tree, in front of station........ 44.9
Huckleberry hill........ 141.
Indian Mills. Bench-mark on oak at cross-roads in front of church........ 75.6
Jacksonville. On stone at northeast corner of road to Jobstown........ 70.6
Jacobstown. Northeast corner of stepping-stone in front of D. L Platt's store, 179.2
Jacobstown. Hill 1 mile northeast of........ 198.
Jemima Mount........ 99.
Jobstown Rail at crossing of Mount Holly turnpike........ 74.2
Kinkora. North rail in front of station........ 10.2
Lewistown. Rail of P. & H. R. R., just west of cross-roads........ 85.5
Lewistown. Hill on road to Brown's Mills, 2 miles southeast of........ 175
Lumberton. On mile-post (2 miles to Mount Holly)........ 23.3

Burlington County—Continued.

Lower Bank. Bench-mark on oak at north end of bridge over river	5.1
Masonville. Bench-mark on maple, in front of post-office	44.1
Maple Shade station. North rail at crossing	40.5
Marlton. Rail at crossing, 300 yards west of station	87.9
Medford. Water-table, northwest corner of bank	65.7
Mount Holly Coast Survey station. Top of the mount	183.
Mount Laurel. Bench-mark on maple, northeast corner of cross-roads	89.1
Mount Laurel. Summit of	173.
New Gretna. Bench-mark on oak at east end of hotel	9.8
New Lisbon. Door-sill of school-house	50.6
Palmyra. South rail at crossing by station	20.5
Pointville. Bench-mark on maple at northeast corner of road, opposite hotel	143.5
Rancocas. On marble stepping-stone in front of store at southwest corner of Main street and road to Centerton	68.1
Recklesstown. Bench-mark on buttonwood at meeting of four roads	91.8
Retreat. Hill 2 miles southeast of	131.
Riverside. South rail at crossing by station	17.1
Riverton. South rail at crossing by station	20.5
Smithville. Bench-mark on oak east side of road, 40 yards south of station	50.8
Stevens' station. South rail at crossing	24.2
Sykesville. Large stepping-stone in front of Newbold's house	191.9
Tabernacle. Cross-roads	101.
Taylor's Mount	140.
Vincentown. Lowest step of bank	29.4
Wading River. Most westerly bolt in northwest wing wall of bridge	7.3
Washington. Bench-mark on oak at corner of roads to Quaker Bridge and Hampton Gate	55.9
Wood Lane station. West rail at crossing	56.7
Woodmansie. North rail at crossing by station	159.9
Wrightstown. Cross on stepping-stone opposite hotel	135 9

Camden County.

Ancora. Bench-mark on large tree south side of railroad at crossing	95.3
Ashland. North rail at crossing by station	72.1
Atco. Bolt on top of hitching-post at south corner of Woodland's store	155.5
Atco. Hill northeast of station	178.
Berlin. West rail at Haddonfield road	155.4
Berlin. Coast survey station	211.
Blackwoodtown. Bench-mark on willow at cross-roads	74.8
Blue Anchor. Bench-mark on large oak in south forks of roads	152.1
Chew's Landing. Bench-mark on cedar near church	27.2
Clementon. North rail at crossing south of station	61.3
Collingswood. South rail of north track at crossing	25.2
Cuthbert's. South rail of north track at crossing	35.4
Dudley. North rail at crossing by station	54.0

Camden County—Continued.

Ellisburgh. On curbstone at northwest corner of cross-roads	58.7
Elm. Rail at crossing by station	98.2
Gibbsborough. Corner of stone wall at southwest corner	99.9
Glenwood. North rail at crossing	49.7
Great Egg Harbor river, at New Brooklyn	104.
Haddonfield. North rail at crossing, one-third mile northwest of station	30.3
Haddonfield. Hill 1 mile south of	140.
Highest point in county, 2½ miles northeast of Berlin	214.
Mount Ephraim. Cross on guard-stone, southwest corner of cross-roads	62.7
Parkdale. Rail at station	59.8
Pensauken station. South rail at crossing	70.0
Pine hill, near Clementon	202.
Sicklerville. Bench-mark on tree, southeast corner of cross-roads	137.7
Spring Mills. Nail in root of tree by post-office	77.4
Summit of C. & A. R. R.	174.
Trout Run station. North rail at	130.0
Waterford. South rail at crossing, one-quarter mile south of station.	116.2
Wilton. South rail at station	164.4

Cape May County.

Beesley's Point. Bench-mark on Mulberry tree, north end of shore road	9.1
Bennett's station. West rail at	18.9
Burleigh. South rail of Anglesea R. R, at shore road crossing	16.7
Cold Spring. North end of north door-sill of Presbyterian church	20.7
Goshen. Bench-mark on tree in front of store at corner	14.6
Highest point in county, 2 miles east of Woodbine	50.
Mount Pleasant. North rail at crossing	33.9
North Dennisville. On stone in front of J. Holmes' house	15.9
Ocean View. South rail at crossing	18.8
Palermo. Bench-mark on oak opposite church	32.0
Rio Grande. Bench-mark on walnut in southwest corner	21.3
Sea Isle Junction. Rail at station	16.0
South Seaville. Rail at station	23.0
Surface of swamp at divide between Dennis and Cedar Swamp creeks	12.
Swaintown. East rail at crossing	18.8
Townsend's Inlet. Top of stone fence-post, northeast corner of M. E. church-yard	25.7
Tuckahoe. On large stone in northwest corner of road to Marshallville	17.5
Woodbine. Rail in front of station	43.5

Cumberland County.

Bacon's Neck station. North rail at crossing	16.5
Belle Plain. South rail at crossing	47.6
Bridgeton. Pond on Cohansey, above	19.
Carlsburg. East rail at station	103.3

Cumberland County—Continued.

Cedar Grove pond	50.
Cedarville. West rail at crossing	53.4
Cumberland pond	30.
Deerfield Street. Bench-mark on maple at west side of road-forks	111.6
Dividing Creek. Bench-mark on maple in front of Dr. Judson's	13.0
Fairton. Rail at station	31.2
Finley station. East rail at crossing	109.7
Gouldtown. Bench-mark on maple in front of house just east of cross-roads	82.4
Greenwich. Bench-mark on large elm at east end of station	15.4
Highest point in county, 2 miles northeast of Deerfield	146.
Hopewell station. South rail at crossing	52.8
Husted station. West rail at	98.7
Jericho. Bench-mark on buttonwood, southeast corner near pond	31.0
Main Avenue station. Rail at crossing	99.6
Manumuskin station. West rail at crossing	17.4
Millville. Wood's lake	26.
Newport. Bench-mark on mulberry tree, north side of road at hotel	8.0
North Vineland. Rail at crossing by station	97.0
Port Elizabeth. Highest guard-stone, southwest corner, opposite school-house	12.8
Port Norris. Rail at station	8.2
Roadstown. Cross on stone, southwest corner of cross-roads	115.5
Rosenhayn station. Rail at crossing	106.7
Sheppard's station. North rail at crossing	13.4
Shiloh. Bench-mark on maple by T. F. Davis' store	116.1
South Vineland. East rail at crossing	93.5
Summit of Bridgeton and Millville turnpike	124.
Vineland, highest ground	121.
Wheat Road station. South rail at crossing	99.6
Woodruff. North rail at station	92.6

Essex County.

Bloomfield. Morris canal, above lock	119.8
Bloomfield. Morris canal, above plane No. 11	173.7
Caldwell. Sill of east door of Presbyterian church	411.0
Cedar Grove. Cross on stone, northeast corner, 100 yards north of store	270.0
Clinton. Stone step at south door of school-house	172.0
Eagle rock	630.
Franklin. Boulder by picket fence at northwest corner	234.8
Highest point in county, Second mountain, back of Caldwell penitentiary	691.
Livingston. Cement at base of flag-staff	315.3
Millburn. Rail at crossing just east of station	151.4
Montclair. Rail at station, D., L. & W. R. R.	240.9
Montclair. Summit of road to Caldwell	509.
Newark. Morris canal, at upper end of plane	100.4
Newark. Morris canal above lock, at Lock street	109.5
Newark, highest ground	235.0

Essex County—Continued.

Northfield. On corner of step at west side church door	265.3
Nutley. West rail in front of station	98.5
Orange. Rail at D., L. & W. station	187.4
Orange, or First mountain. Summit of	665.
Orange storage reservoir	329.
Orange reservoir	329.
Pine Brook. Cross on stone under southwest end of porch of Frank Class' hotel	173.6
Pleasantdale. Large boulder at north corner of cross-roads	423 5
Riker's hill. West of Livingston	473.
Roseland. Guard-stone, corner of graveyard back of church	369.3
Short Hills. Rail at station	207.6
South Orange. Rail at station	141.8
Upper Montclair. West rail at crossing south of station	341.7
Verona. East corner of top step leading to cellar of store	356.2
Watchung Mountains. Summit of First	665.
Watchung Mountains. Summit of Second	691.

Gloucester County.

Almonesson. Bench-mark on maple tree, 30 yards northwest of cross-roads	48.2
Asbury station. East rail at crossing	55.2
Barnsboro. Bench-mark on maple near hotel pump	151.4
Barnsboro hill	152.
Bridgeport. Cross on guard-stone at southwest corner of Main street and road to Swedesboro	22.8
Clarksboro North rail at crossing by station	54.0
Clayton. Rail at crossing just south of station	126.1
Cross Keys. Bench-mark on willow at	150.4
Evans' Mills. Bench-mark on maple opposite blacksmith shop, southwest coruer of cross-roads	110.2
Fairview hill	142.
Five Points. Bench-mark on chestnut, 25 yards west of Rulon's hall	153.
Forest Grove. North rail at crossing just north of	106.2
Franklinville. Rail at crossing	107.1
Green Tree. Hill at	155.
Glassboro. Rail of Bridgeton branch, at crossing south of station	146.3
Glassboro. Chestnut ridge	171.
Hardingville. Bench-mark on maple in front of Siloam M. E. Church	146.1
Harrisonville. Cross on guard-stone, northeast corner opposite Wriggins' store,	85.3
Highest point in county, 1 mile southeast of Cross Keys	177.
Hurffville. On horse-block in front of Mr. Hurff's house	78.4
Iona Bench-mark on maple, northwest corner of roads, just east of station	112.7
Jefferson. Large stone at corner	147.5
Jefferson. Hill just east of	166.
Lippincott hill. South of Battentown	143.
Malaga. Rail at crossing near station	106.1

Gloucester County—Continued.

Mantua. On stone across ditch opposite toll-gate	31.2
Mickleton station. North rail at crossing	55.2
Mount Royal station. North rail at crossing	34.1
Mullica Hill. Cross on flagstone step of town hall, close to iron post	96.9
Mullica Hill road station. West rail of crossing	43.1
Newfield. Rail at crossing just north of station	115.7
Ogden station. West rail at crossing,	13.8
Parkdale station. East rail at crossing	37.2
Paulsboro. Rail at crossing east of station	9.9
Pitman Grove. Rail at crossing by station	135.3
Porchtown. Bench-mark on hickory at corner just east of pond	88.2
Repaupo. Bench-mark on maple, northeast corner of cross-roads	20.6
Salina. Cross on northeast end of long stone in front of gate of house on northeast corner of cross-roads	66.3
Sewell station. Rail at crossing	19.8
Tatem's station. East rail at crossing	56.8
Thorofare. South rail at crossing by station	19.8
Tomlin station. East rail at crossing	42.9
Turnersville. Bench-mark on tree at cross-roads by toll-gate	59.3
Unionville. Rail at station	145.1
Wenonah. Rail of west track at main crossing	59.3
Westville station. East rail of north-bound track at crossing	9.1
Williamstown. West rail at crossing north of station	157.1
Williamstown. Highest point in	164.
Wolfert station. North rail at crossing	49.5

Hudson County.

Arlington. Rail at station	62.0
Bergen Point. Corner of Avenue S and Third street	37.
Guttenberg. Summit of hill. Highest point in county	263.
Homestead station. Rail of N. J. N. R. R., at crossing	4.9
Secaucus. Stone, southwest corner of roads to Clarendon and Snake Hill	41.4
Snake hill	203.
Stevens' Castle hill	100.
Tyler Park. Rail of N. J. N. R. R., at crossing south of station	5.8
Union. Curb at southeast corner of Bergen Line avenue and Fulton street	174.5
Weehawken. Hill just west of West Shore terminus	183.

Hunterdon County.

Anthony. Top of sharp rock on southeast, opposite Beatty's store	815.5
Baptisttown. Brownstone stepping-stone in front of house just south of hotel,	513.73
Califon. Rail at station	484.0
Centerville. Top of guard-stone, northeast corner of cross-roads	103.8
Cherryville. Bench-mark on maple at cross-roads	670.8
Cherryville. Highest ground at	706.

Hunterdon County—Continued.

Clinton. Water-table, southeast corner of "Clinton National Bank"	196.1
Clover Hill. Cross on stone at southwest corner of cross-roads	186.0
Cokesbury. Highest point of stone bridge at	604.0
Copper Hill. East rail in front of station.	161.9
Croton. Cross on stone 6 yards from guide-post	508.3
Cushetunk mountain	839.
Everittstown. Summit of stone wall at north end of bridge, opposite wheelwright shop	262.1
Fair Mount. Highest point of stone step at north corner of store	672.5
Fox Hill. U. S. Coast Survey station west of Fair Mount	1035.
Frenchtown. Projecting window-sill of bank, 3.6 feet above pavement	131.5
Frenchtown. Delaware river at	101.
Goat hill. South of Lambertville	497.
Glen Gardner. Guard-stone, north corner of cross-roads	412.8
Gravel hill	865.
Hamden. North abutment at southeast corner of bridge over South Branch	164.9
Hamden. South Branch below dam	156.
High Bridge. Rail at station	329.4
Highest point in county, summit of county line between the Musconetcong and South Branch of the Raritan	1073.
Holland station. Delaware river just below	113.
Junction. Frog at junction of D., L. & W. R. R. and N. J. C. R. R.	508.4
Kingwood. Northeast corner of stepping-stone in front of Presbyterian church	523.5
Lebanon. Rail at station	293.1
Little York. Crow's-foot on stone in forks of roads	355.7
Locktown. Corner, 100 yards north of store	477.
Milford. Rail at crossing near station	135.6
Milford. Delaware river at	108.
Mountainville. On stone at southwest corner of bridge	410.0
Mountainville. Hill just east of	957.
Musconetcong. Delaware river at mouth of Musconetcong river	129.
Musconetcong. Mountain summit near Swinesburg	987.
New Germantown. Pointed stone at stoop of store at northeast corner of cross-roads	260.6
New Hampton. Sill of door in end of mill	357.4
Oak Dale. Bench-mark on large oak at entrance to lane, north of railroad, just west of Bowne station	165.1
Oak Grove. On stone at center of cross-roads	525.8
Pattenburg. Rail in front of station.	457.1
Pattenburg. Hill over Musconetcong tunnel, L. V. R. R.	943.
Pickles mountain	839.
Pittstown. Bench-mark on rock, east side of road alongside of mill race	374.8
Pleasant Run. Arrow pointing to summit of guard-stone on northeast corner,	149.2
Point Pleasant. Delaware river at	69.
Readington. Northeast corner of southwest wall of bridge over Holland's branch	103.3

Hunterdon County—Continued.

Reaville. Cross on stone marked 1876, in front of hotel	186.6
Rosemont Stone in front of north door of M. E. church	321.6
Round mountain. East of Stanton	608.
Sand Brook. Cross on southeast abutment of bridge on Flemington road	309.5
Sergeantsville. Cross on horse-block, southwest corner of cross-roads	344.7
Sourland mountain. Buttonwood Corners	560.
Stanton. Lowest step of post-office	364.7
Stockton. Top of stepping-stone in front of hotel	83.3
Stockton. Delaware river at	52.
Three Bridges. North rail of S. Br. R. R., at crossing	107.2
Three Bridges. North Branch at	87.
Tumble. Delaware river, 1½ miles above	91.
Valley. Whitewashed guard-stone, southeast corner of barn opposite hotel	425.5
Van Syckle's. Guard-stone at northwest corner of cross-roads	298.2
White Hall. Large rock at west end of store stoop	967.1
White House Station. West rail of south-bound track at station	176.3

Mercer County.

Asylum station. East rail at crossing Belvidere R. R	58.9
Divide between Stony brook and Assanpink creek	60.
Dutch Neck. Road at corner by church	99.
Ewingville. Arrow on stone opposite school-house	183.3
Hamilton Square. Water-table of brick store on corner	109.6
Harbourtown. Top of corner-stone, northwest corner of cross-roads	290.5
Highest point in county, summit of hill east of Moore's station	473.
Hightstown. Cross on stone, southwest corner in front of Railroad Hotel	84.9
Hopewell. Cross on flagstone opposite school-house	183.3
Lawrence Station. West rail at	62.4
Lawrenceville. Arrow on stone at northeast corner, northeast of church	123.2
Lawrenceville. Hill northwest of	192.
Marshall's corner. Hill south	460.
Moore's station. Stone at gate-post, by willow, at entrance to lane near station	56.6
Moore's station. Delaware river at	29.
Mount Canoe	442.
Mount Rose. Bolt in top of post near southwest corner of cross-roads	310.3
Mount Rose Coast Survey station	415.
Pennington. Main cross-roads	210.
Port Mercer. Stony brook at	53.
Princeton. Summit of ground at	227.
Princeton Junction. Rail at crossing southwest of station	87.5
Robbinsville. Rail at crossing	121.8
Scudder Falls station. West rail at railroad crossing	58.9
Titusville. South rail at railroad crossing near station	60.2
Trenton. Delaware and Raritan canal, below lock No. 2	8.7
Trenton. Delaware and Raritan canal, above lock No. 2	18.4

Mercer County—Continued.

Trenton. Delaware and Raritan canal, above lock No. 3	30.7
Trenton. Delaware and Raritan canal, above lock No. 4	42.4
Trenton. Delaware and Raritan canal, above lock by prison	50.9
Trenton. Delaware and Raritan canal, above State street lock	56.3
Washington's Crossing. East rail at railroad crossing	59.3
Washington's Crossing. Delaware river at	24.
Wilburtha. West rail at railroad crossing	59.0
Wilburtha. Delaware river at	15.
Windsor. Bench-mark on maple at cross-roads	104.2
Yardville. Cross on northwest corner of foundation of store at cross-roads	59.8

Middlesex County.

Browntown. Hill 1½ miles east of	208.
Cranbury. Granite block under most northerly wooden pillar of the white church	102.4
Cranbury station East rail at railroad crossing just south of	122.1
Dayton station. North rail at railroad crossing	104.5
Dean's station. East rail of east track at railroad crossing	103.2
Dunellen Rail at station	54.9
Franklin Park. Large flat stone in front of church	132 5
Helmetta. North rail at crossing by station	42.9
Highest point in county, summit of the Sand hills, northwest of Monmouth Junction	293.
Hoffman station. North rail at railroad crossing	81.3
Iselin. East rail of main track at railroad crossing	56.3
Menlo Park. West rail of main track at railroad crossing northeast of station,	78.4
Milltown. On water-table at southwest corner of M. E. church	49.3
Morgan station. East rail of south-bound track at railroad crossing	9.8
New Brooklyn. Rail at railroad crossing near station	80.7
New Market. Stone at corner opposite hotel.	64.6
Old Bridge. West rail at railroad crossing near station	15.5
Plainsboro. Road monument, center of cross-roads	91.20
Poplar hill, east of Metuchen	233.
Prospect Plains. Stepping-stone in front of Railroad Hotel	126.1
Sayreville. South end of flagstone sill, entrance of Sayreville Hall	29.5
South River Cross on flat corner-stone, southeast corner, near Voorhees' hotel,	10.37
Spotswood Rail at crossing near station	28.7
Stelton. Mile-stone on west side of New Brunswick road, just southwest of cross-roads	113.2
Tracey's station North rail at railroad crossing	84.8

Monmouth County.

Allaire station Joint of south rail at railroad crossing	52 6
Allentown. Bench-mark on tree in front of Union Hotel	82.2
Allenwood. South rail at main railroad crossing	64.8
Beacon Hill	373.

Monmouth County—Continued.

Black's Mills. Pond	113.
Chapel Hill	211.
Clarksburg. Arrow on stone at corner of road to Hightstown	231.5
Cliffwood station. West rail of north-bound track at crossing	61.0
Colt's Neck. Bench-mark on locust at corner by tavern	73.6
Cream Ridge. East rail at crossing by station	115.7
Davis. East rail at crossing by station	120.7
Eatontown. Rail at crossing of turnpike	31.8
Ellisdale. On stone at southeast corner opposite store	93.4
Fair Haven. Bench-mark on maple, northeast corner of cross-roads	27.0
Hamilton. On stone at southwest corner of Old church	102.0
Hazlet. South rail of east-bound track at railroad crossing	70.7
Highest point in county, Crawford's hill	391.0
Highlands of Navesink. Highest point	260.
Holmdel. Cross on southwest corner of stone step at west entrance to Reformed church	101.0
Hornerstown. East rail at railroad crossing north of station	84.5
Howell. South rail at railroad crossing	124.7
Imlaystown. On flagstone of bridge guard	105.7
Lower Squankum. Bench-mark on locust at corner near post-office	42.8
Manalapan. Bench-mark on willow at south corner of cross-roads	150.2
Marlboro. Bench-mark on tree at northeast corner of cross-roads just west of,	169.9
Middletown. Bench-mark on tree at corner	41.9
Morganville. Rail at station	120.0
Navesink. Cross on curb at corner by W. Swan's store	60.7
New Bedford. Bench-mark on poplar in cross-roads by hotel	52.9
New Monmouth. Bench-mark on large stepping-stone in churchyard	40.4
Oceanic. Most easterly cross-roads	13.
Perrineville. Stone at southwest corner, foot of locust tree	183.2
Pine hill	364.
Red Valley. Long imbedded stone at corner	147.0
Robertsville. Bench-mark on willow, southwest corner of cross-roads	131.5
Scobeyville. Arrow on stone, northwest corner of roads	74.9
Shrewsbury. Rail at railroad station	48.3
Southard. Forks of road at store	120.0
Tennent. North rail at railroad crossing	89.3
Throckmorton hill. Two and one-half miles south of Colt's Neck	308.
Tinton Falls. Cross on stone step of residence on southwest corner of cross-roads	44.7
Turkey. On corner-stone supporting stringer of bridge at northwest corner, foot of mill-pond	86.8
Vanderburg. Bench-mark on large maple at corner	86.6

Morris County.

Afton. Door-sill of brick school-house	195.5
Bald hill. West of Pompton Plains	964.
Bald mountain. East of Rockaway	903.

Morris County—Continued.

Bartley. West rail at crossing by railroad station	635.3
Boonton. Morris canal, above lock east of	398.9
Boonton. Morris canal, above plane	480.7
Boonton. Morris canal, above upper lock	489.6
Boonton. Morris canal, above lock No. 8, east	504.5
Boonton falls. Head of	481.
Bowling Green mountain	1391.
Brookside. Top of stone, east end of north parapet of bridge over Dismal brook	405.5
Brook Valley. Brook in front of store	633.
Budd's lake	933.
Buck mountain. East of Splitrock	1107.
Chatham. Rail at railroad station	233.9
Chester. Stone water-table of hotel	860.3
Convent station. Rail at railroad crossing	381.3
Copperas mountain. Summit of	1243.
Denmark pond	818.
Denville. Morris canal, above lock No. 7, east	511.8
Dixon's pond	560.
Dover. Morris canal, above lock No. 6, east	581.2
Drakesville. Rail at station	797.3
Drakesville. Morris canal, above the planes	863.5
Drakesville. Morris canal, above plane No. 4, east	725.4
Durham pond	880.
Flanders. Stone step at small white house opposite Nichols' store	727.9
German Valley. South end of stone at east side of sink, opposite mill	545.0
Green pond	1045.
Green pond mountain. Summit of	1300.
Green Village. Bench-mark on tree, southeast corner	253.2
Hanover. Corner near church	213.
Hanover Neck. Cross on stone at east corner	196.6
Hibernia. Guard-stone, northwest corner of Richards, Beach & Co.'s store	551.2
Highest point in county, summit of Bowling Green mountain	1391.
Hook mountain	456.
Horse hill	493.
Ironia. West rail of Chester Branch railroad, just north of station	705.2
Kakeout mountain. Southwest of Butler	1050.
Lake Hopatcong. Surface of water when full	927.7
Lake Hopatcong. Morris canal, below outlet lock	913.0
Lincoln Park. Morris canal, below lock	174.9
Lincoln Park. Morris canal, above lock	181.7
Lincoln Park. Morris canal, above plane No. 10, east	237.9
Littleton. Stepping-stone in front of white house on southwest corner of roads	366.3
Long hill. Guard-stone at northeast corner	245.1
Long hill. Summit of	508.
McCainsville. Rail of High Bridge branch at crossing by railroad station	725.1

Morris County—Continued.

Madison. Rail at railroad station	247.8
Mendham. Bench-mark on elm in front of First Presbyterian Church	649.1
Middle Valley. Rock under east gate-post at north corner	510.2
Millington. Arrow on coping-stone, southeast wing wall of bridge over river	224.8
Middle Forge pond	708.
Milton. Southeast corner of stone under southeast corner of platform of store opposite hotel	822.9
Mine Hill. Guard-stone by steps of J. Bones' hotel	863.8
Montville. Morris canal, above planes	388.0
Mooseback pond	810.
Morris Plains. Rail at railroad station	405.7
Mount Fern	1003.
Mount Freedom. Wooden door-sill of Presbyterian church	944.4
Mount Hope. Conglomerate boulder in front of store (at end of railing)	828.9
Mount Olive. U. S. Coast Survey station	1150.
Mount Paul	806.
Mount Tabor. Rail at railroad station	532.6
Naughright. Highest point of coping of south parapet of bridge over river	569.0
New Vernon. Stone door-step of school-house	345.9
Parker. Bench-mark on second cherry tree south of southeast corner of cross-roads at school-house	902.0
Parsippany. Water-table, northeast corner of brick church	331.4
Passaic river, at Horse Neck bridge	162.
Passaic river, at Pine Brook bridge	162.6
Passaic river, at Swinefield bridge	164.
Passaic river, at Lower Chatham bridge	167.
Passaic river, north of New Providence	203.
Passaic river, at Millington bridge	214.
Petersburgh. South corner of stone door-step of mill	770.1
Petersburgh pond	772 0
Pequanac. Rail at railroad crossing	180.6
Pleasant Grove. Rock in middle of road in front of store	940.9
Pompton Plains. Rail at railroad crossing	193.2
Pompton river, at Pompton Plains	169.
Pompton station. Rail of N. Y. & G. L. R. R. at crossing near station	223.6
Port Oram. Morris canal at	665.2
Rockaway. Morris canal, above plane	563.1
Schooley's Mountain. Highest step of entrance to residence opposite Belmont Hall	1015.7
Schooley's Mountain. Summit west of Budd's lake	1227.
Sheep hill	935.
Shongum pond	698.
Snake hill. South of Rockaway	811.
Stanhope. Morris canal, below plane	786.9
Stanhope Morris canal, below lock 1 mile west of	776.1
Splitrock pond	815.

Morris County—Continued.

Stickle pond	783.
Stirling Rail at crossing	227 5
Succasunna. Platform under northwest column of portico of Presbyterian church	717.7
Trowbridge mountain	1082.
Troy Hills. Cross on large stone under elm tree.	241.8
Whippany Arrow on flat stone at north corner near hotel	205.4
Watnong mountain. U. S Coast Survey station	983.

Ocean County.

Bamber. Rail in front of railroad station	97 6
Bayville Bench-mark on large oak in front of M E. church..	40.2
Bennett's Mills. Bench-mark on apple tree at cross-roads, one-eighth mile north of	93.5
Burrsville. Bench-mark on willow by store	29 3
Cassville. Bench-mark on buttonwood by store	124.3
Cedar Creek. Bench-mark on large oak, east side of main shore road, opposite mile-post	12.8
Collier's Mill. Stone at northeast corner of cross-roads	143.5
Forked River Round stone in sidewalk just south of Presbyterian church	16.9
Forked River mountains	182.
Highest point in county, 2 miles west of Cassville	226.
Jackson's Mills. Pond at	90.
Lakewood East rail at crossing just north of railroad station	53.7
Manahawken. Bench-mark on oak near E. Pridmore's store	27.1
Manchester. East rail at crossing just north of railroad station	65.1
Mayetta. East rail at railroad crossing	19.4
New Egypt. Rail at railroad station	73.6
Osborneville. Bench-mark on oak by Benj. Fisher's store	13.9
Prospertown. Big stone at northwest corner of cross-roads	105.8
Silverton. Bench-mark on oak at southwest corner of cross-roads	15.3
Staffordsville. East rail at railroad station	29.1
Van Hiseville. Bench-mark on locust at cross-roads	103.7
West Creek. East rail at crossing north of railroad station	23.6
West Point Pleasant. Bench-mark on hickory, at place where five roads meet..	16.2
Wheatland. South rail at most easterly street crossing	153.1

Passaic County.

Athenia. Rail at Erie station	134.0
Bearfort mountain	1490.
Bloomingdale. Stone horse-block in front of Union Hotel	295.6
Bloomingdale. Pequannock river at.	284.
Buckabear pond	992.
Charlotteburgh. North rail at station	718.5
Charlotteburgh pond	697.

Passaic County—Continued.

Cedar pond	1113.
Clifton. Rail at Erie station	66.3
Cooper. Extreme west end of stone of dam, outlet of lake	624.0
Dunker pond	1010.
Echo lake. Top of boulder, 4 feet from corner of fence of Brown's hotel	985.8
Garret Rock	533.
Great Notch	303.
Greenwood lake. High-water level	624.
Hank's pond	1030.
Hewitt. Bench-mark on oak at road corner, south of furnace	413.1
High mountain. North of Paterson	879.
Highest point in county, summit of Bearfort mountain	1490.
Kanouse mountain	1195.
Little Falls. Passaic river, above dam	158.
Little Falls. Passaic river, below rapids	118.
Macopin lake	890.
Midvale. Step of bar-room door of Tice's hotel	253.4
Mud pond	337.
Negro pond	610.
Newfoundland. South rail at railroad crossing east of station	774.7
Oak Ridge. Rail at railroad station	856.3
Passaic. Rail at main railroad station, N. Y., L. E. & W. R. R	57.4
Passaic Falls. River above	110.
Passaic Falls. River below rapids	38.
Pompton. Sill of Reformed church	208.0
Pompton lake	202.
Ringwood. Deck of bridge over Ringwood creek	339.
Sheppard's pond	634.
Singac. Rail at crossing near station	169.6
Smith's Mills. South rail at crossing	440.2
State line mile-stones.	
19th	777.6
20th	760.
24th	781.8
25th	863.8
26th	627.8
27th	1369.
28th	1280.
Tice's pond	470.
Upper Macopin. Large rock under east end of road bridge, 30 yards south of store	1066.5
Wanaque. Rail at crossing by railroad station	238.5
Wanaque river, below dam at Wanaque	212.
Weasel. U. S. Coast Survey station	596.
West Milford. Large conglomerate rock, southwest corner of fence, north of church	704.8
Winbeam mountain	1023.

Salem County.

Acton station. South rail at railroad crossing	18.1
Aldine. Cross on door-sill of M. E. church	130.2
Alloway. Bench-mark on buttonwood, south side of hotel	38.5
Alloway pond	13.
Alloway station. South rail at railroad crossing	24.9
Auburn. At meeting of three roads	76.
Big Mannington hill	127.
Burden's hill	138.
Canton. Bench mark on maple, southeast corner of cross-roads	23.6
Centerton. Bench-mark on willow opposite hotel	80.3
Centerton mill-pond	79.0
Cohansey. Bench-mark on maple, southwest corner of cross-roads	108.3
Daretown pond	93.
Elmer mill-pond	104.
Fenwick station. East rail at railroad crossing	62.9
Hancock's Bridge. Cross on west end of south pier of bridge over creek	5.3
Harmersville. Bench-mark on maple, east side of cross-roads	18.6
Highest point in county, 2 miles northeast of Whig Lane	166.
Lower Penn's Neck. Highest point on	19.
Monroeville station. Rail at railroad crossing	135.5
Newkirk station. North rail at railroad crossing	128.3
Oakland station. South rail at railroad crossing	56.5
Palatine station. West rail at railroad crossing	109.1
Paulding station. South rail at railroad crossing	112.1
Pedricktown. Guard-stone at southeast corner of cross-roads	14.0
Penton station. South rail at crossing	20.9
Penns Grove. South rail at Main street crossing	6.0
Perkintown station. South rail	24.8
Pennsville. Corner by Moore & Wheaton's store	9.
Pittsgrove. Bench-mark on tree, northwest corner near school-house	135.6
Point Airy	151.
Quinton. Cross on curb in front of Hires & Co.'s store.	8.8
Sharptown. Bench-mark on maple in front of old hotel	22.3
Shirley. Cross-roads	144.
Union Grove mill-pond	66.
Whig Lane. Bench-mark on maple, northeast corner of cross-roads	143.2
Willow Grove mill pond	72.
Woodstown. Hill 2 miles southeast of	149.
Yorktown. Bench-mark on cedar, south of railroad and 100 yards west of railroad station	111.2

Somerset County.

Basking Ridge. Stone water-table, southwest corner of Presbyterian church	338.5
Bedminster. Stone step of post-office	177.0
Bedminster. North branch at	130.
Belle Mead. North rail of north track, crossing north of railroad station	99.8

Somerset County—Continued.

Bernardsville. Rail at railroad station	368.2
Blackwell's Mills. Cross on boulder, southeast corner of roads on east side of river	44.9
Blawenburgh. On slate slab in front of store	157.5
Bloomington. Delaware and Raritan canal, below lock	25.1
Flagtown. South rail of South Branch railroad, at crossing	123.8
Griggstown. Delaware and Raritan canal, below lock	40.9
Harlingen. Cross on stone inscribed with names of building committee, at west side of steps of Reformed church	94.8
Highest point in county, summit of Mine mountain	837.
Kingston. Delaware and Raritan canal, below lock	48.8
Lamington. Stone at southwest corner of picket fence, just west of church	146.2
Liberty Corner. Stone in wall in front of hotel, 2.7 feet from largest tree	215.3
Martinsville. Cross on horse-block in front of house on northwest corner	315.7
Middlebush. South rail at crossing near station	105.1
Millstone. Cross on guard-stone at northwest corner of roads, opposite hotel	45.4
Millstone river, at Millstone	26.
Montgomery. Cross on small culvert at northeast corner of cross-roads	120.1
Mount Horeb. U. S. Coast Survey station	594.
Neshanic Station. (South Branch railroad.) South rail at station	86.6
Peapack. Top of coping at southwest corner of bridge by mill	242.0
Pluckamin. Top of stone, southeast corner near yard fence	183.8
Pluckamin. North branch of Raritan, at bridge north of	105.
Rocky Hill. Summit near Ten-mile run	321.
Roycefield. North rail of South Branch railroad, at crossing by station	102.4
Second Mountain, 2½ miles northwest of Mount Horeb	653.
Sourland mountain. Summit of	563.
South Branch. Coping, end of northeast wing wall of bridge over river	62.5
South Branch. River at	54.
Stoutsburgh. West rail at railroad station	177.3
Warrenville. Bench-mark on cedar, just north of school-house	383.3
Weston. Delaware and Raritan canal, below ten-mile lock	32.5
Woodfern station. North rail at railroad crossing	83.3

Sussex County.

Augusta. East rail at crossing	498.5
Allamuchy mountains, summit of	1248.
Bear ponds	977.
Beemerville. Cross on old foundation of wheelwright shop	755.2
Bevans. Stone sill of main entrance to hotel	499.0
Canistear, at corner	1061.
Catfish pond	440.
Cranberry reservoir	771.
Creamery station. East rail at crossing, L. & H. R. R.	531.0
Culver's gap, summit of road in	915.
Culver's pond	848.

Sussex County—Continued.

Davis' pond	581.
Decker pond	806.
Dingman's ferry. Delaware river at	356.
Flatbrookville. Delaware river at Decker's ferry	319.
Franklin Furnace pond	530.
Fredon. Bench-mark on walnut 30 yards northeast of corner	653.8
Glenwood. Bench-mark on maple near school-house	724.4
Hamburgh. East rail at crossing by railroad station	421.9
Hamburgh. Wallkill river at	402.
Hamburgh mountains. Summit of	1496.
Hewitt's pond, near Andover	573.
Highest point in county, High Point, Kittatinny mountain	1804.
Highest point of the Highlands in New Jersey, 3 miles south of Vernon	1496.
Hopewell, pond at	1060.
Howell's pond, Pinkneyville	579.
Hunt's pond	675.
Huntsville. Bench-mark on elm at northeast corner near river	582.6
Iliff's pond	577.
Kays. Rail at railroad station	512.5
Lake Marcia, near High Point	1570.
Libertyville. Cross on stone at northeast corner of cross-roads	742.5
Lincoln. Large flat rock opposite hotel	633.3
Long pond, near Culver's gap	861.
Long pond, near Andover	576.
Mashipacong pond, on Kittatinny mountain	1124.
McAfee. West rail at railroad crossing	434.2
Monroe. West rail of L. & H. R. R. at crossing near station	544.2
Morris pond, near Sparta	929.
Mount Salem. State line monument at road north of	872.0
Mud pond, Hamburgh mountain	1244.
Mulford's station. East rail of L. & H R. R. at crossing	595.3
Ogdensburgh. Rail at station	664.2
Ogdensburgh. Wallkill, 1 mile above	567.
Panther pond, south of Andover	766.
Papakating crossing. West rail of N. Y., S. & W. R. R.	395.9
Pimple hills. Summit of	1088.
Plumbsock. Pyramid-shaped stone, corner of fence just south of store	660.4
Pochuck mountain. Summit of	1176.
Port Jervis. Delaware river at mouth of the Neversink river	409.
Port Jervis turnpike. Summit of, on Kittatinny mountain	1530.
Quarryville. East rail at railroad station	556.9
Quick pond, foot of Kittatinny mountain	943.
Round pond, Kittatinny mountain	1359.
Rutherford lake, or Sand pond, west of Coleville	1300.
Sand pond, south of McAfee	1244.
Smith's Ferry, Delaware river	324.

Sussex County—Continued.

Sparta. Top of stone in sub-foundation at southeast corner of Presbyterian church	713.7
Sparta mountain. Summit of	1406.
Stag pond	820.
Stanhope reservoir	859.
State line mile-stones.	
29th	1109.0
30th	1001.2
31st	777.2
32d	429.4
33d	510.7
34th	435.9
35th	391.5
36th	822.3
37th	871.7
38th	390.1
39th	398.4
40th	508.0
41st	575.9
42d	757.6
43d	703.
44th	915.8
45th	1022.5
47th	872.1
48th	555.2
Stickle pond.	587.
Stillwater. Arrow on south end of step leading to Presbyterian church	442.8
Stockholm. Guard-stone, northeast corner of J. M. Lewis' store	982.5
Stockholm, summit of N. Y., S. & W. R. R. west of	1029.
Sucker pond	911.
Swartswood. Cross on stone opposite corner to McDonald's store	538.3
Swartswood lake, surface of water	480.
Tranquility station. East rail at crossing	568.0
Turtle pond	573.
Vernon. Bolt in guard-stone, corner of fence, east of Denton's store	561.6
Wallpack Centre. Arrow on conglomerate rock, west side of cross-roads	452.8
Wallpack Centre. Delaware river 2 miles above Buck bar.	329.
Washington, or Hunt's Mills. Cross on stone in triangle of roads	621.8
Wawayanda. On irregular gneiss rock, southwest corner of bridge over race, on road to Greenwood lake	1118.0
Wawayanda lake	1150.
Wawayanda mountain, summit of, also the summit of the Highlands	1496.
White lake	572.
White's pond	575.
Wright's pond	743.

Union County.

Berkeley Heights. Rail at crossing by railroad station	230.6
Cranford. Rail in front of station	72.7
Highest point in county, Second mountain north of Feltville	553.
Lyons Farms. Rock at east side of road, 4 feet from fence, near school-house	73.5
Murray Hill. Stream at road, just north of railroad	225.
New Providence. High guard-stone in front of hotel	217.3
Plainfield. Center of door-sill, main entrance Second Presbyterian church	106.8
Sayre Coast Survey station. Benedict's hill, northeast of Cranford	180.
Scotch Plains. Bench-mark on elm, northeast corner of bridge by mill	151.5
Springfield. Top of mile-stone, M. and E. turnpike	100.0
Summit. Rail at station	387.0
Union. Door-sill of church	103.8
Washington Rock, near Plainfield, top of rock	507.
Westfield. Rail at station	127.8

Warren County.

Allamuchy. Corner of wall at west side of gate in front of white house	636.7
Allamuchy pond	775.
Anderson. Sill of front door of store opposite hotel	451.9
Asbury. Crow's-foot on flat rock at junction of roads north of mill	343.3
Asbury. Musconetcong river, below dam	311.
Bald Pate. Upper Pohatcong mountains	1192.
Beatyestown. Top of flat stone across lower end of drain opposite mill	485.6
Beatyestown. Musconetcong river	461.
Belvidere. Delaware river, head of rapids, 1½ miles south of	221.
Belvidere. Delaware river, below rapids, 2 miles south of	213.
Belvidere. Delaware river at mouth of Pequest creek	229.
Blairstown. South rail at crossing near railroad station	351.3
Blairstown. Paulin's Kill at	334.
Broadway level of Morris canal	433.4
Brotzmanville. Delaware river at Walker's ferry	296.
Calno. Bench-mark on elm at corner, just north of Mill brook	359.7
Calno. Delaware river, 1½ miles above Depew island	306.
Catfish pond	1179.
Carpentersville. East rail at station	175.6
Cedar lake	381.
Changewater. First stone in first course above ground at up-stream corner of south abutment of railroad bridge	376.6
Changewater. Musconetcong river	361.
Columbia. East rail at railroad crossing	307.9
Columbia. Delaware river at mouth of Paulin's Kill	265.
Columbia. Delaware river, 1½ miles above	277.
Danville. North end of door-sill of Presbyterian church	524.7
Delaware. Top of stone slab in front of gate of Presbyterian church	288.4
Delaware. River at Meyer's ferry	252.
Dunnfield. Rail at crossing west of station	314.0

Warren County—Continued.

Glover's pond	569.
Green's pond	399.
Hainesburg. Rail at crossing	307.2
Hardwick church. Guard-stone at north corner of graveyard	877.3
Harmony. Summit of road between Upper and Lower Harmony	568.
Hazen. Rock at west side of flag-staff	380.5
Highest point in county, Kittatinny mountain, one mile northeast of Water Gap	1635.
Hope. Guard-stone, 5 feet from east end of north wing wall of bridge over Beaver brook	414.5
Hughesville. Musconetcong river, just above	195.
Jacksonburgh. Cross on stone at corner	389.
Jenny Jump mountains. Highest point	1141.
Johnsonburgh. Southwest corner of stone door-step of hotel	573.8
Kalarama. Rail at crossing	370.
Karrsville. Stone door-sill of school-house	570.2
Knowlton. Cross on flagstone, entrance to basement of post-office	714.1
Lopatcong. Morris canal, foot of plane No. 10, west	216.6
Lopatcong. Morris canal, above plane No. 10, west	261.8
Marble mountain	770.
Marksborough. Corner of flange at bottom of cast-iron pillar of brick store	505.7
Martin's Creek station. Delaware river	186.7
Millbrook. Red stone by fence at east corner of cross-roads	652.7
Montana. Top of monument at U. S. C. S. station	1240.0
Mount Hermon. Cross on boulder at southeast corner	492.8
Mount Mohepinoke	1140.
Mount No More	1145.
Paulina. Arrow on lowest stone step, outside of gate, 100 yards west of corner	349.0
Petersburgh. Bench-mark on elm, 37 yards northeast of cross-roads	707.2
Phillipsburgh. Delaware river at	156.
Pohatcong mountain. Summit	898.
Polkville. Cross on stone near northeast corner of cross-roads	585.8
Port Colden. Morris canal, above lock	516.9
Port Colden. Morris canal, above plane No. 6, west	567.1
Port Murray. Morris canal, above plane No. 5, west	630.0
Port Warren. Morris canal, above plane No. 9, west	361.2
Riegelsville. On southeast wing wall of bridge over the Musconetcong	150.2
Riegelsville. Delaware river at	129.
Sand pond, near Warren and Sussex county line	973.
Saxton's Falls. Morris canal, below lock	630.8
Saxton's Falls. Morris canal, below lock No. 4, west	632.1
Saxton's Falls. Morris canal, above lock No. 4, west	639.4
Scott's mountain. Summit of	1277.
Shoemaker's Ferry. Delaware river at	300.
Shuster's pond	433.
Silver lake	419.
Stewartsville. Morris canal, above plane No. 8, west	423.3

Warren County—Continued.

Springtown. Pohatcong creek at bridge	192.
Sunfish pond	1375.
Townsbury. Lowest step in wall in front of house on south side of road between the bridge and corner of road to Buttzville	492.0
Townsbury. Pequest creek	483.
Uniontown Cross on stone at forks of roads	376.0
Upper Pohatcong mountain. Summit of	1230.
Vienna. At corner of road to Petersburgh	536.
Walnut Valley. At cross-roads	345.
Warrenville On rock opposite opening of road to Saxton Falls	859.9
Warrington. Rail at crossing	298.5
Washington. Morris canal, above plane No. 7, west	506.8
Water Gap. Delaware river opposite Water Gap House	287.
Water Gap. Brow of mountain on New Jersey side	1486.
White pond	449.

ELEVATION OF VARIOUS TOPOGRAPHICAL FEATURES.

Minisink Valley.

This valley has the Delaware river as its main axis from Port Jervis to Delaware Water Gap. The river falls quite uniformly from 409 feet elevation at the New York line, to 287 feet at the Water Gap. The valley lands rise generally to about 500 feet elevation.

Kittatinny Mountain.

The elevation of the crest line varies from a maximum of 1804 feet at High Point to 915 feet at Culver's gap. The highest point on the Deckertown and Port Jervis turnpike is 1,530; just west of Beemerville it is 1,650; one mile north of Round pond, in Wallpack township, it is 1,614; east of Catfish pond it is 1,575; Catfish Pond gap is 1,200, and about one mile east of the Water Gap it is 1,635 feet. The mountain traverses the State for a length of 40 miles with a width of from one to five miles. Together with Minisink valley it occupies an area of 135 square miles in New Jersey.

Kittatinny Valley.

The main, or lowest axis of this valley is 385 feet elevation at the New York state line, 501 feet at its highest, near Augusta, and 270 at the junction of the Paulinskill and Delaware near Columbia.

The flat or bottom lands of the valley, covering considerable areas, range from 400 to 600 feet elevation. The drowned lands of the Wallkill are at about 400 feet; Vernon valley about the same; Papakating valley, 420; Paulinskill meadows, near Newton, 560; Germany Flats, about 620; Pequest meadows, 520; and the undulating valley lands in Warren county along the Delaware below Belvidere to Phillipsburgh, range from 300 to 400 feet. The slate and limestone hills and ridges rise on the northwestern side of the valley to 1,000 feet and upward; on the southeast side they range from 700 to 900 feet. The ruling elevations may be said to be from 400 to 600 feet for the plains and bottom lands of the valley, and from 800 to 1,000 feet for the hills and ridges. Probably 700 feet is not far from the average elevation of the whole valley.

The width of the valley is 12 miles, with little variation; it lies entirely within the State for 40 miles of its length and the eastern border continues within from Manunka Chunk to Phillipsburgh, 15 miles farther. It comprises about 500 square miles of superficial area of the State.

The Highlands.

This group of ridges and plateaus covers 900 square miles of the State, being about 60 miles in length, from northeast to southwest, and from 9 to 18 miles in width. The maximum elevation is reached at a point about midway between Canistear and Vernon, 1,496 feet above sea-level. The summit of Bearfort mountain, is 1,490, almost as high. Several points in the Wawayanda and Hamburgh mountains are over 1,400 feet. The summit of Sparta mountain, two miles southwest of Stockholm, is 1,406; but no points south and east of those above mentioned reach 1,400. There is a gradual descent from these elevations, toward the southeast border, where the Ramapo mountain reaches a maximum of 1,171; and also southwestward, the summit of Musconetcong mountain being 987, and its southwest end, near Delaware river, less than 800. Bowling Green mountain, near Milton, is 1,391; Hopatcong mountain, east of Lake Hopatcong, ranges from 1,243 to about 1,000; Alamuche mountain, from 1,248 to about 1,000; Schooley's mountain, from 1,227 near Budd's lake, to about 900 near the Central railroad in Hunterdon county. In Warren county, Upper Pohatcong mountain ranges from 1,230 to about 800; Pohatcong mountain from 898 to about 700; Scott's mountain from 1,277 to about 900.

Jenny Jump mountain has an elevation of 1,141, and Pochuck mountain of 1,224. Both of these belong geologically with the Highlands but are isolated from the main group.

Of the ridges of Green Pond mountain conglomerate, Bearfort has a maximum of 1,490 and nowhere falls below 1,300 on the main-ridge summits; Kanouse mountain ranges from 1,195 to less than 900; Green Pond mountain reaches 1,300, is mostly above 1,200, but falls southwest to about 900; Copperas mountain has a maximum of 1,251 and is generally above 1,200. These ridges are notable for their level crests and extremely broken surfaces.

The portion of the Highlands east of Bearfort and between the Pequannock river and the New York line, ranges from 1,242 to about 900, not including a few lower peaks near Wanaque valley.

East of Green Pond and Copperas mountains, between the Pequannock and Rockaway rivers, the summits range from 1,169 near Marcella, to about 800; there are a few lower, but many between 800 and 1,100. The valleys of the Rockaway and its branches range between 500 and 700 feet in elevation.

Between the Rockaway and Black or Lamington rivers the maximum elevation is 1,082 feet near Mount Freedom; many summits range from 800 to 1,000, but along the southern border they fall off to 600 feet or less in elevation.

Fox hill ranges from 1,035 to about 700, with a few lower summits along the southern border.

Most of the Highlands valleys range between 500 and 800 feet in elevation. The lower portions of the Pohatcong, Musconetcong and Wanaque valleys are less than 500 feet.

The average elevation above sea-level of the Highlands region, does not vary much from 1,000 feet. The ridges and plateaus are from 500 to 1,000 feet higher than the adjacent valleys.

Passaic Valley.

There are large areas of flat bottom lands in this valley, covering in all some 60 square miles, which lie between 170 and 240 feet elevation. Nearly three-fourths of these flats lie between 170 and 200 feet. The whole area of the valley is about 200 square miles so that the flat portions comprise about one-third. A few of the higher hills, mostly trap rock, range between 400 and 500 feet, but by far the larger part of the upland of the valley is below 400.

Watchung Mountains.

The maximum elevation is High mountain, a peak of Preakness mountain, north of Paterson, 879 feet above the sea. From this, Preakness mountain ranges down to about 400 feet. Goffle mountain ranges from 521 to 400. Camp Gaw hill is 752. Between Paterson and Summit, Second mountain lies between 550 and 691; First mountain between 500 and 665. From Summit southwest, First mountain is between 450 and 539, and Second mountain between 530 and 635. These ridges are remarkable for their continuous and nearly level crests.

Palisades Mountain.

The maximum elevation is 547 feet near Closter, thence the ridge descends quite uniformly to only about 40 feet elevation in the city of Bayonne. The highest point of the escarpment of the Palisades proper is 530 feet above the Hudson.

Sourland Mountain.

The summit is near the northeast end, 563 feet above tide. The mountain does not generally fall below 450 on its crest line.

Cushetunk or Pickles Mountain.

This horseshoe shaped ridge reaches 839 feet above tide and is mostly above 600.

West Hunterdon Plateau.

The greatest elevation of this red sandstone plateau is 913 feet; at Cherryville it is 706 and thence it falls gently to about 500 feet near Delaware river.

Rocky Hill.

The greatest elevation is 415 feet, near Mount Rose. The ridge falls eastward near Millstone river to 274; is cut through to its base by the river and rises again on the east to 321.

Hackensack Valley.

The main axis of this valley is 45 feet above tide at the New York State line; thence it falls to tide level at New Milford, and from Englewood and Hackensack southwest is occupied by a broad belt of tide-marsh about level with mean high tide. North of Paterson there is a district generally above 300 feet elevation, ranging upward to 610 feet; between Passaic river and Orange or First mountain there is a region mainly above 150 and partly as high as 300 feet; elsewhere the valley is below 200.

Raritan Valley.

The larger part of this valley is below 200 feet elevation. Along the base of the Highlands, at Peapack and New Germantown, and between the Highlands and Cushetunk mountain, as well as along the eastern foot of the latter, there is some country which ranges from 200 to 400 feet or over.

Southern New Jersey.

The highest point in all of southern New Jersey, is Crawford's hill, one of the Mount Pleasant hills, between Keyport and Holmdel, in Monmouth county, 391 feet above the sea. The Highlands of Navesink rise to 259, and the hills between Clarksburgh and Perrinesville to 354. These three localities have considerable ground above 200 feet elevation, but aside from these there are only about a dozen small gravel knolls which rise to 200 feet. Something over one-half of the whole area is below 100 feet. The main divide falls a little below 100 feet between the Rancocas and Mullica headwaters, and between Assanpink creek and Millstone river it is only 60 feet at the lowest. The average elevation of southern New Jersey is not far from 100 feet.

The Tidal Plain.

The area of tide-marsh in the State, including creeks less than 100 yards in width, is 296,500 acres. The included bays and creeks over 100 yards wide cover 125,570 acres, making a total of about 660 square miles for the whole tidal plain. The marsh corresponds in

elevation, generally, to the level of the highest tide, since when it ceases to be overflowed it ceases to receive sediment and increase in elevation. This level does not necessarily correspond with high-water level in the ocean, however, for high water in the bays is usually much lower. The inlets are too contracted to allow the bays to fill up to the level of high water outside, so high water inside of the beaches ranges from one to nearly two feet lower. It is not unusual, therefore, to find the marsh more than a foot lower than mean high water in the ocean outside. For the same reason the marsh is found to be low near the upland at the head of the long tidal creeks on Delaware bay shore.

Where the marshes have been embanked and improved they have shrunk considerably. Instances have been noted where this shrinkage or settlement amounts to three feet.

In this connection, the following list of observed elevations of tide-marsh and of high, mean and low tides in the bays and creeks, will prove of interest. At Sandy Hook, the United States Coast and Geodetic Survey has taken a series of observations, with a self-registering tide-gauge, extending continuously from October 21st, 1875, to October 31st, 1881. The mean of all the readings of this series is taken as mean sea-level at this place and is the datum-plane (the zero) for all elevations. This series of observations makes the mean rise and fall of the tide at Sandy Hook 4.7 feet. The gauge was placed at the New Jersey Southern railroad wharf on the inner side of the Hook.

The observations were made during the progress of the leveling operations of the Topographic Survey. Those marked U. S. C. S. are based on tidal observations made by the United States Coast Survey and connected by these levels. They are most reliable. The others, on high water, are as accurate as they could be made without a series of observations to determine the mean high-water mark. It should be remarked that as the inlets are constantly changing their cross-sections, it is hardly probable that mean high water in the several bays rises to the same height two years in succession.

Elevations of Tide-Marsh, High, Mean and Low Water Referred to Mean Tide at Sandy Hook.

LOCALITY.	ELEVATION IN FEET.			
	TIDE-MARSH.	HIGH WATER.	MEAN TIDE.	LOW WATER.
Sandy Hook, U. S. C. S.	....	2.35	0.00	-2.35
On Overpeck creek, Nordhoff station	2.46	....	....	....
" " " Leonia station	2.77	....	....	....
" " " opposite Palisades Park	2.29	....	....	....
" " " north of Ridgefield	2.58	....	....	....
Hackensack river, at Hackensack	....	3.22	....	....
Little Ferry	2.60	2.60	....	....
One mile south of Little Ferry	2.30	....	....	....
Bellman's creek, at N. Y., S. & W. railroad	....	2.70	....	....
New Durham	1.96	....	....	....
Erie railroad, west of tunnel, Jersey City	2.73	....	....	....
East of Harrison, near turnpike (embanked)	-0.90	....	....	....
Waverly, half mile north of station	2.06	....	....	....
Elizabeth river, at Pennsylvania railroad	....	2.48	....	....
Rahway river, at Rahway	....	2.56	....	....
Woodbridge, at railroad, south of village	3.28	....	....	....
Woodbridge creek, Woodbridge and Sewaren road	3.02	....	....	....
Mouth of Cove's Mill creek, north bank of Raritan	3.08	....	....	....
Cheesequakes creek, at railroad bridge	2.45	....	....	....
Perth Amboy, Lewis street	....	2.40	....	....
One-quarter mile northwest of Matawan	2.84	....	....	....
Flat creek; road from Keyport to Keansburg	3.14	....	....	....
Two miles west of Port Monmouth	....	2.76	....	....
Red Bank, Navesink river, 1884	....	1.62	....	....
Clay-pit creek, Navesink river, 1884	....	1.76	....	....

LOCALITY.	ELEVATION IN FEET.			
	TIDE-MARSH.	HIGH WATER.	MEAN TIDE.	LOW WATER.
Parker's creek, 1 mile north of Oceanport, 1884	1.91	....	....	....
Manasquan river, north side	2.05	....	....	....
Mantoloking, on Barnegat bay	1.40	....	....	....
Bay Head, Barnegat bay	0.98	0.67	....	....
Metedeconk river, 1 mile east of Cedar bridge, range of tide about 0.70 ft	....	0.85	....	....
Kettle creek; U. S. C. S., gives range of tide, 0.47	....	....	....	....
Toms river, U. S. C. S., observations of 1876, west of Island Heights	....	0.89	0.52	0.16
Toms river, 1885, at village bridge	....	0.80	....	....
Seaside Park, U. S. C. S., 1876, range of tide, 0.88	....	....	....	....
Cedar creek, 1885, at shore road	....	2.76	....	....
Cedar creek, U. S. C. S. observations, 1874, range of tides, 0.75	....	....	....	....
Waretown (Barnegat bay)	....	1.31	....	....
Barnegat. End of Bay avenue	1.40	....	....	....
Barnegat Landing, on Double creek, range of tides, U. S. C. S. observations, 1874, 0.75	....	....	....	....
Barnegat inlet, range of tides in the bay, 2.04, from U. S. C. S. observations, 1866	....	....	....	....
Inside of Long Beach, 1 mile south of Barnegat inlet	1.26	....	....	....
Near Harvey Cedars	1.65	....	....	....
Near railroad at Cedar Bonnets	1.89	....	....	....
Long Beach railroad draw-bridge, Manahawken bay	....	0.94	....	....
Near Long Beach railroad, west side of Manahawken bay	1.94	....	....	....
Dinner Point, U. S. C. S., 1873, gives range of tide, 2.21 feet	....	....	....	....
Osborne's island, north side of Great bay	....	1.59	....	....
Great bay, mouth of Mullica river	....	1.94	....	....

LOCALITY.	ELEVATION IN FEET.			
	TIDE-MARSH.	HIGH WATER.	MEAN TIDE.	LOW WATER.
Willett's house, north shore of Great bay, 1 mile back from New inlet	2.21	....	....	....
Willett's house, from U. S. C. S. observations of tides in Great bay, 1872. (Compare above for 1885)	....	2.70	1.00	-0.70
[For reason for this change of about -0.70 in height of high water, see maps showing changes at New inlet, in report for 1885.]				
Wharf at Bond's Long Beach house, range of tide 2.35 feet, from U. S. C. S. observations, 1873	....	....	....	....
Oswego river, at Bridgeport, 1884	....	1.42	....	....
Mullica river, at Lower Bank bridge, 1884	....	1.45	....	....
Mullica river, at Gloucester landing, 1884	....	1.26	....	....
Port Republic, Nacote creek, 1884	....	1.80	....	....
Absecon creek, shore road, 1883	....	1.75	....	....
Absecon bay, west side, 1883	2.17	....	....	....
Absecon inlet, range of tide inside of beach, 3.95, from U. S. C. S. observations, 1872	....	....	....	....
Atlantic City, draw-bridges	2.08	....	....	....
Great Egg Harbor bay, Somers Point, April, 1883	....	2.01	....	....
Great Egg Harbor bay, Somers Point, September 8th, 1885	....	2.05	....	....
Great Egg Harbor bay, mouth of Tuckahoe river	2.36	....	....	....
Tuckahoe bridge, 1884	2.37	....	....	....
End of shore road, Beesley's point, 1884	2.46	....	....	....
Great Egg Harbor bay, mouth of Great Egg Harbor river	2.06	....	....	....
Lake's creek, English creek road	....	2.52	....	....
English creek, at English Creek village	....	2.84	....	....
Gibson's creek, Gibson's Landing	3.37	2.79	....	....
Great Egg Harbor river, mouth of Miry run	....	2.40	....	....
Steelman's Landing, Estellville creek	....	2.50	....	....

LOCALITY.	ELEVATION IN FEET.			
	TIDE-MARSH.	HIGH WATER.	MEAN TIDE.	LOW WATER.
South river, Mays Landing and Estellville road	....	1.01	....	....
Great Egg Harbor river, High Bank Landing	....	2.20	....	....
Great Egg Harbor river, Mays Landing	....	2.00	....	....
Embanked meadow, Mays Landing	(1.51)	....	....	....
Corson's inlet	2.67	....	....	....
Sea Isle City	2.56	....	....	....
Ocean View, at Van Gilder's mill-pond, 1884	1.74	....	....	....
Jenkins' sound, Shell-bed landing, 1884	2.40	....	....	....
Cape May Landing, 1884, from a short series by the U. S. C. and G. S.	....	2.05	-0.15	-2.35
Fishing creek, Delaware bay shore, 1884	2.59	....	....	....
Dyer's creek, bay shore road, 1884	2.60	....	....	....
Dennis creek landing, embanked meadow, 1884	(1.37)	....	....	....
Mauricetown, Maurice river, 1884	....	2.32	....	....
Manantico creek, Millville and Port Elizabeth road	....	3.25	....	....
Maurice river, Millville	....	3.10	....	....
Dividing creek, Port Norris road	1.16	1.96	....	....
Oranoken creek, Beaver Dams (very low meadow)	0.77	....	....	....
Cedar creek, Cedarville	....	2.77	....	....
Nantuxent Neck, near edge of upland	2.70	....	....	....
Fortesque road, near edge of upland	2.37	....	....	....
Fortesque Beach, U. S. C. S. observations, 1880, give as range of tides 6.00 ft.	....	....	....	....
Sea Breeze, U. S. C. S. observations, 1880, give as range of tides 6.18 ft.	....	....	....	....
Sea Breeze road, near edge of upland	2.75	....	....	....
Greenwich wharf, Cohansey creek	3.40	3.40	....	....
Buena Vista, embanked meadow	(-0.46)	....	....	....
Fairton (embanked meadow on Mill creek)	(0.39)	3.55	....	....

LOCALITY.	ELEVATION IN FEET.			
	TIDE-MARSH.	HIGH WATER.	MEAN TIDE.	LOW WATER.
Cohansey creek, 1½ miles below Bridgeton, embanked	(–0.12)	....	....	....
Cohansey creek, Bridgeton	....	3.30	....	....
Bayside	3.71	2.76	....	....
Strathem's Neck	2.91	....	....	....
Strathem's Neck, embanked meadow	1.04	....	....	....
Stow creek, 1 mile below Canton	2.69	2.61	....	....
Canton, embanked meadow	0.42	....	....	....
Stow Neck	2.84	....	....	....
Stow Neck, recently-embanked meadow	(2.11)	....	....	....
Alloway's Creek Neck, 3 miles below Hancock's Bridge,	1.58	....	....	....
Alloway's creek, Hancock's Bridge	....	1.92	....	....
Alloway's creek, Quinton	....	2.49	....	....
One and a half miles west of Hancock's Bridge, embanked	–0.83	....	....	....
One and a half miles northeast of Elsinborough Point, embanked	–1.57	....	....	....
Half mile west of Salem, embanked	–1.99	....	....	....
Salem creek, at Salem	....	3.30	....	....
Salem creek, 2 miles below Sharpstown	....	2.30	....	....
Raccoon creek, at Swedesboro	....	3.06	....	....
Timber creek, Westville	....	3.35	....	....
Philadelphia, Old Navy Yard, U. S. C. S. observations of 1878, compared by bench-mark at Swanson and Reed streets	....	2.67	-0.34	-3.34
Rancocas creek, Mount Holly	....	3.33	....	....
Delaware river, Burlington	....	3.80	....	....
Delaware river, Bordentown	....	3.70	....	....

NOTE.—When no other date is given, observations were made in 1885, 1886 and 1887.

Elevations Along River Courses.

Delaware river at Port Jervis, mouth of Neversink, 409; at Milford, Pa., 385; at Dingman's, Pa., 356; at Flatbrookville, 319; at Water Gap, 287; at Columbia, 270; at Delaware, 252; at Belvidere, 229: at Martin's Creek, 185; at Phillipsburg, 156; at Musconetcong, 129; at Milford, N. J., 108; at Frenchtown, 101; at Byram, 69; at Stockton, 52; at Washington's Crossing, 24; at Trenton, 0; Trenton is the head of tide water and navigation.

Passaic river at outlet of Great Swamp, above Millington, 221; at New Providence, 203; at Chatham, 177; at Pine Brook, 163; above Beatty's dam, Little Falls, 158; at foot of rapids, 118; at head of Passaic falls, 110; at foot of rapids, Paterson, 38; above Dundee dam, 27; at Passaic, 0; the head of tide and of navigation is Passaic.

Raritan river, at Budd's lake, the source, 933; at German Valley, 530; at High Bridge, 230; at Clinton, 190; at Three Bridges, 90; at junction of North Branch, 48; at Bound Brook, 17; at New Brunswick is the head of tide and navigation.

DRAINAGE AREAS, FORESTED AREAS AND POPULATION (1880) OF STREAM BASINS.

	Square miles.	Percentage of forest.	Population per square mile.
WALLKILL, TO STATE LINE.†	210.1	20	41
Pochuck creek, to State line	53.7	55	25
Wawayanda lake	6.5	64	35
Papakating creek	62.2	14	58
Wallkill to Franklin Furnace	31.3	51	26
Morris pond	1.5	66	....
HACKENSACK RIVER, TOTAL WATER-SHED	201.6	*36	216
Hackensack above New Milford	114.8	*60	125
Hackensack above Pascack creek	58.0	....	....
Hackensack in New York	64.1	....	152
Pascack creek	28.0	....	....
Musquapsink creek	7.0	....	....
PASSAIC RIVER, TOTAL WATER-SHED	949.1	*44	338
Passaic river above Dundee dam	822.4	....	....
Passaic river above falls at Paterson	796.9	....	85
Passaic river above Little Falls	772.9	....	....
Passaic river in New York	148.6	....	42
Second river	17.2	10	1,400
Third river	14.4	23	276
SADDLE RIVER, TOTAL WATER-SHED	60.7	*28	122
Saddle river in New York	8.0	....	84
Hohokus creek above Hohokus	15.7	34	59
POMPTON RIVER, TOTAL WATER-SHED	379.9	*69	48

† Includes Pochuck creek. * Percentage of portion lying within New Jersey.

	Square miles.	Percentage of forest.	Population per square mile.
RAMAPO RIVER, TOTAL WATER-SHED	160.7	*72	58
Ramapo in New York	112.4	....	52
WANAQUE RIVER, TOTAL WATER-SHED	109.6	*83	30
Wanaque in New York	28.2	....	22
Greenwood lake, total water-shed	28.0	*81	26
Greenwood lake in New York	10.2	....	22
PEQUANNOCK RIVER	84.8	78	42
Pequannock above Macopin intake	63.7	....	....
Macopin lake	2.5	50	30
Pequannock to Oak Ridge reservoir	27.6	....	....
Stickle pond	1.7	100	....
Mossman's brook to Clinton reservoir	9.9	....	....
Hank's pond	.7	100	....
Cedar pond	1.0	100	....
Buck-a-bear pond	1.2	100	....
Dunker pond	2.7	70	15
ROCKAWAY RIVER, TOTAL WATER-SHED	138.4	80	110
Rockaway above Boonton	118.2	82	113
Stony brook	12.7	....	....
Shongum pond	2.9	65	138
Beaver brook	22.1	....	....
Splitrock pond	5.3	98	5
Green Pond brook	16.4	87	51
Green Pond brook to Middle Forge	10.1	....	....
Green pond to outlet	1.7	82	....
Rockaway above Port Oram	29.9	90	42

* Percentage of portion lying within New Jersey.

	Square miles.	Percentage of forest.	Population per square mile.
WHIPPANY RIVER	71.1	36	124
Troy brook	15.2	34	87
Whippany above Morristown	25.4	55	107
PASSAIC ABOVE CHATHAM	99.8	23	121
Passaic above Millington	53.6	26	140
Passaic above Franklin	9.2	....	....
ELIZABETH RIVER TO LAKE URSINO	17.4	13	228
RAHWAY RIVER	83.3	24	338
Robinson's branch	22.8	22	183
Rahway river above Rahway city	41.0	30	350
West branch of Rahway above Orange reservoir	5.0	44	70
RARITAN RIVER	1,105.3	16	105
SOUTH RIVER	132.8	25	83
Manalapan brook to junction with Matchaponix	42.2	19	84
Matchaponix brook	45.2	14	86
LAWRENCE'S BROOK ABOVE WESTON'S MILLS	45.0	17	59
RARITAN ABOVE NEW BRUNSWICK	895.2	13	93
Bound Brook, including Green brook	61.5	22	330
Middle brook above Chimney rock	16.7	24	43
MILLSTONE RIVER	285.7	9	78
Beden's brook	49.9	11	59
Stony brook	64.8	8	79
Millstone above forks of Stony brook	98.8	12	75
NORTH BRANCH OF RARITAN	191.6	13	72
Lamington or Black river	91.8	14	80
Lamington above Pottersville	33.0	....	....

	Square miles.	Percentage of forest.	Population per square mile.
Rockaway creek	39.4	12	66
North Branch above forks of Lamington	63.6	16	79
North Branch above Peapack brook	29.1	....	....
SOUTH BRANCH OF RARITAN	276.5	13	79
South Branch to Califon	56.0	....	....
South Branch and Turkey brook	11.3	....	....
Neshanic river	56.3	6	81
Spruce run, including Mulhockaway creek	41.2	15	83
Budd's lake	4.5	24	62
NAVESINK RIVER	95.0	....	....
Swimming river above Red Bank	65.4	11	58
Hockhockson brook above Tinton Falls	11.7	52	51
SHREWSBURY RIVER TO SEABRIGHT BRIDGE	29.0	....	....
WHALE POND BROOK	5.1	35	151
DEAL LAKE	6.1	....	....
SHARK RIVER, TO BRIDGE AT HEAD OF BAY	16.9	59	162
WRECK POND	12.8	29	118
MANASQUAN RIVER	80.5	....	....
Manasquan above Upper Squan bridge	64.7	32	82
METEDECONK ABOVE BURRSVILLE	73.9	68	25
North Branch of Metedeconk	43.2	....	....
South Branch of Metedeconk	29.5	....	....
South Branch of Metedeconk above Lakewood	24.5	75	18
TOMS RIVER ABOVE VILLAGE BRIDGE	163.8	94	17
Toms river above Ridgway branch	58.0	....	....
Toms river above White's bridge	45.0	....	....

	Square miles.	Percentage of forest.	Population per square mile.
Ridgway branch	64.9	....	....
Union branch	30.0	....	....
Horicon branch to Manchester pond	21.0	....	....
Davenport branch to Van Schoick's mill	34.0	....	....
CEDAR CREEK ABOVE VILLAGE	55.8	99	7
Cedar creek to Double Trouble	44.8	....	....
FORKED RIVER ABOVE VILLAGE	14.7	98	7
MILL CREEK ABOVE MANAHAWKEN	19.7	97	6
WESTECUNK CREEK ABOVE WEST CREEK BRIDGE	21.0	96	5
TUCKERTON CREEK ABOVE TUCKERTON	11.9	93	25
MULLICA RIVER	569.6	90	22
Bass river above New Gretna road	16.8	95	11
Wading river	188.9	97	7
East branch of Wading river	65.5	98	6
West branch of Wading river	92.1	99	7
Mullica river above forks of and including Batsto river	221.6	88	19
Atsion and Mechescatauxin to Batsto	73.2	....	....
Batsto river to Batsto	69.1	....	....
Nescochague to Pleasant Mills	35.0	....	....
Hammonton brook to Pleasant Mills	18.3	....	....
ABSECON CREEK ABOVE ABSECON	18.3	97	8
PATCONG CREEK ABOVE STEELMANSVILLE	22.1	81	53
GREAT EGG HARBOR RIVER	337.7	88	21
Great Egg Harbor river above Mays Landing	215.8	88	26
Great Egg Harbor river above Weymouth	192.0	....	....
Great Egg Harbor river above New Jersey Southern railroad	51.0	....	....

	Square miles.	Percentage of forest.	Population per square mile.
Hospitality Branch	50.5	....	....
Babcock's creek, Mays Landing	21.2	98	12
Deep run to forks	22.6	....	....
South river, Monroe forge	19.0	....	....
Stephen's creek to Estellville	10.5	....	....
TUCKAHOE RIVER	99.8	81	15
Tuckahoe river above Tuckahoe	60.2	95	9
MAURICE RIVER	386.4	70	72
Buckshutem creek	18.8	....	....
Manumuskin creek	38.7	94	17
Manantico creek	38.7	79	38
Maurice river above Millville	218.4	67	63
Maurice river above Landis avenue	114.1	66	55
Maurice river, West branch to Rosenhayn	53.1	....	....
COHANSEY CREEK	105.4	20	140
Cohansey creek above Bridgeton	45.8	13	54
DELAWARE RIVER IN NEW JERSEY	2,344.8	30	129
ALLOWAYS CREEK ABOVE HANCOCK'S BRIDGE	51.6	27	58
Alloways creek above Alloway	21.9	....	....
SALEM CREEK	113.6	10	123
Salem creek above Sharptown	22.6	8	112
OLDMAN'S CREEK	44.4	14	52
Oldman's creek above Auburn	26.3	18	46
RACCOON CREEK	44.4	12	91
Raccoon creek above Swedesboro	32.2	12	68
Raccoon creek above Mullica Hill	13.1	....	....

	Square miles.	Percentage of forest.	Population per square mile.
MANTUA CREEK	51.2	16	106
Mantua creek above Berkeley	46.7	17	83
BIG TIMBER CREEK	59.3	25	83
North branch of Big Timber creek	19.8	27	68
South branch of Big Timber creek	25.5	27	62
COOPER'S CREEK	40.5	16	208
Cooper's creek, south branch	18.1	21	62
Cooper's creek, north branch	11.7	16	65
PENSAUKEN CREEK	35.4	10	109
South branch of Pensauken	14.9	12	118
North branch of Pensauken	17.1	7	71
RANCOCAS CREEK	341.4	61	58
South branch of Rancocas	167.1	57	40
Haynes creek	77.1	....	....
South branch above Vincentown	53.3	....	....
North branch of Rancocas	143.7	75	62
North branch to New Lisbon	31.2	....	....
Mt. Misery brook to New Lisbon	75.1	....	....
ASSISCUNK CREEK	45.3	4	58
BLACK'S CREEK TO MANSFIELD SQUARE POND	20.7	....	....
CROSSWICKS CREEK	139.2	20	52
Crosswicks creek to Walnford	79.9	....	....
Doctor's creek to Yardville	26.7	....	....
Doctor's creek to Allentown	17.3	....	....
Back creek to Lowry's pond	8.0	....	....

	Square miles.	Percentage of forest.	Population per square mile.
ASSANPINK CREEK	89.6	9	253
Assanpink to Lawrence station	34.7	....	....
Miry run	13.0	....	....
JACOB'S CREEK	13.3	9	72
ALEXSOCKEN CREEK	14.9	18	60
WICKECHEOKE CREEK	26.9	13	67
LOCKATONG CREEK	23.8	15	45
NICHISAKAWICK CREEK	10.5	13	45
HARIHOKAKE CREEK	10.1	13	46
HAKIHOKAKE CREEK	17.4	16	48
MUSCONETCONG RIVER	157.6	39	71
Musconetcong above Hackettstown	74.6	....	....
Musconetcong above Saxton Falls	68.0	....	....
Musconetcong above New Hampton	122.4	....	....
Musconetcong above Warren Mills	149.9	....	....
Lubber's run	24.1	87	15
Lake Hopatcong	25.4	94	30
POHATCONG CREEK	56.2	19	129
LOPATCONG CREEK	13.5	....	....
PEQUEST RIVER	158.2	18	58
Pequest at Townsbury	83.4	....	....
Pequest at Tranquility	34.8	....	....
Beaver brook	37.1	18	47
Beaver brook at Hope	9.4	....	....
PAULINSKILL	177.4	27	54
Paulinskill at Balesville	66.3	....	....

	Square miles.	Percentage of forest.	Population per square mile.
Swartswood lake	16.3	22	33
Culver's pond	6.3	83	30
Long pond	2.5	80	30
FLAT BROOK	65.7	54	21
Big Flat brook to Forks	33.0	....	....
Little Flat brook to Forks	16.5	....	....
*Delaware at Port Jervis	3,252	....	....
Delaware below mouth of Neversink	3,600	....	....
Delaware at Water Gap, above Broadhead's creek	4,020	....	....
Delaware at Belvidere, below Pequest	4,708	....	....
Delaware at Easton, above Lehigh river	4,880	....	....
Delaware at Easton, below Lehigh river	6,212	....	....
Delaware at Bull's Falls	6,750	....	....
Delaware at Lambertville	6,820	....	....
Delaware at Scudder's Falls	6,894	....	....
Delaware at Trenton	6,916	....	....
Delaware at Philadelphia	8,186	....	....
Delaware below mouth of Schuylkill	10,100	....	....

* These areas of the Delaware water-shed are taken from Prof. Geo. F. Swain's report in Volume 16, Tenth Census, and appear to be as nearly correct as existing surveys will admit of.

SURFACE AREAS AND TRIBUTARY DRAINAGE AREAS OF LAKES AND PONDS.

	Area of Water Surface—Acres.	Drainage Area—Square Miles.
ATLANTIC COUNTY.		
Bargaintown, lower pond	73	20.66
Bargaintown, upper pond	57	11.77
Gloucester lake	85	23.58
Mays Landing mill-pond	333	215.8
Pleasant Mills, south pond	51	....
Weymouth mill-pond	205	192
BERGEN COUNTY.		
Franklin lake	89	2.41
Rotten pond	25	1.06
BURLINGTON COUNTY.		
Atsion mill-pond	77	43.71*
Batsto, east pond	89	69.7
Brown's Mills pond	45	27.03
Hanover Furnace pond	103	13.12
Harrisville mill-pond	101	155
CUMBERLAND COUNTY.		
Bridgeton mill-pond	85	45.8
Millville mill-pond	926	218.4
Willow Grove mill-pond	118	....
ESSEX COUNTY.		
Orange reservoir	64	4.80
GLOUCESTER COUNTY.		
Clayton mill-pond	69	7.84
Malaga Furnace pond	92	27.86
MIDDLESEX COUNTY.		
Weston's Mills pond	64	45
MONMOUTH COUNTY.		
Como lake	50	1.26
Deal lake	144	6.16
Silver lake	14	.26
Spring lake	18	.30
Sunset lake	18	....
Takanassee lake (Whale pond)	29	5.1
Wesley lake	18	....

* Includes 18.02 from Mechescatauxin by a canal.

MORRIS COUNTY.	Area of Water Surface—Acres.	Drainage Area—Square Miles.
Budd's lake	475	4.5
Denmark pond	172	4.5
Dixon's pond	35	3.5
Durham pond	47	....
Green pond	460	1.7
Hopatcong lake	2,443	25.4
Middle Forge pond	96	10.1
Mooseback pond	21	....
Petersburg mill-pond	53	....
Shongum pond	70	2.9
Splitrock pond	315	5.3
Stickle pond	110	1.7
OCEAN COUNTY.		
Carasaljo lake (Lakewood)	97	24.80
Cook's pond	22	....
Little Silver lake	16	.24
Manahawken mill-pond	98	19.7
Old Sam's pond	28	....
Twilight lake	21	....
PASSAIC COUNTY.		
Buck-a-bear pond	59	1.2
Cedar pond, recently enlarged	218	1
Charlottesburgh mill-pond	42	....
Clinton reservoir—Newark water works	423	9.5
Dunker pond	17	2.7
Dundee lake	224	8.22
Greenwood lake (total area)	1,920	28
Hank's pond	75	.7
Macopin lake	299	2.5
Mud pond	28	....
Negro pond	69	1.04
Oak Ridge reservoir—Newark water works	383	27.3
Pompton lake	196	159.5
Sheppard's pond	97	.76
Tice's pond	20	.65
SALEM COUNTY.		
Alloway mill pond	122	21.9
SUSSEX COUNTY.		
Bear ponds	38	.58
Buckmire pond	10	.75
Catfish pond (near Stillwater)	14	.40
Cranberry reservoir	154	3.02

	Area of Water Surface—Acres.	Drainage Area—Square Miles.
Culver's pond	486	6.3
Davis pond	14	.51
Decker pond (Pochuck mountain)	76	.38
Franklin Furnace pond	55	31.3
Hewitt's pond	35	5.15
Hopewell Furnace pond	24	1.01
Howell's pond	26	.21
Hunt's pond	37	2.12
Iliff's pond	36	3.38
Lane's pond, or Grinnell lake	67	1.15
Little pond (Swartswood)	100	3.11
Long pond (near Culver's gap)	299	2.5
Long pond (near Andover)	117	4.76
Long pond (Kittatinny mountain)	13	.46
Losee pond	137	......
Marcia lake	23	.14
Mashipacong pond	46	.77
Morris pond	136	1.5
Mud pond (Hamburg mountain)	28	.36
Panther pond	41	.47
Quick pond	43	.50
Roe pond	23	......
Round pond (Kittatinny mountain)	33	.29
Rutherford lake	65	.65
Sand pond (Hamburg mountain)	32	.48
Stag pond	23	.30
Stanhope reservoir	339	4.9
Stickle pond	35	.87
Sucker pond	95	1.15
Swartswood lake	505	16.3
Turtle pond	13	.10
Waterloo pond	68	......
Wawayanda lake	240	6.5
White lake	17	......
White's pond	11	......
Wright's pond	31	3.36

WARREN COUNTY.

Allamuchy pond	56	1.80
Catfish pond	31	.65
Cedar lake (near Blairstown)	27	1.25
Glover's pond	13	.28
Green's pond	117	5.15
Sand pond	14	.69
Shuster pond	14	.64
Silver lake	35	3.37
Sunfish pond	41	.31
White pond	67	.67

AREAS OF TIDAL WATERS.

	Acres.
Hudson river and New York bay, in New Jersey	12,048
Newark bay	5,126
Raritan bay, in New Jersey	35,274
Navesink river, Highlands to Seabright and Red Bank	2,502
Shrewsbury river above Seabright bridge	2,202
Shark river bay	1,018
Manasquan river	1,216
Barnegat bay, Bay Head to Cedar Bonnets	46,289
Little Egg Harbor bay, Cedar Bonnets to Little Egg Harbor light	20,103
Great bay	11,347
Little and Grassy bays	2,969
Reed's bay	2,502
Absecon bay	1,440
Lake's bay	1,792
Scull's bay	627
Great Egg Harbor bay, not including Peck's bay	4,832
Ludlam's bay	960
Great sound	1,542
Jenkins' sound and Genesis bay	730
Delaware bay in New Jersey, below Cohansey light	207,448

YIELD OF STREAMS.

The following are estimates based on many observations. The figures are for natural flow, not interfered with by diversion or holding of water back in ponds.

NAME OF STREAM.	YIELD IN MILLION GALLONS EACH 24 HOURS.		
	GREATEST.	LEAST.	AVERAGE.
Delaware at Trenton	a 167,225	880	8,161
Delaware at Phillipsburgh	120,000	600	5,758
Delaware at Water Gap	105,000	494	4,744
Delaware at Port Jervis	81,000	435	3,837
Paulinskill	2,630	14	206
Pequest	1,290	11	184
Musconetcong	1,260	15	184
Wallkill at State line	1,240	14	182
Hackensack at New Milford	2,900	14	118
Hackensack at mouth	5,000	30	208
Passaic at mouth	11,000	100	963
Passaic at Dundee	10,950	88	834
Passaic at Paterson	10,950	86	809
Passaic at Little Falls	10,950	85	785
Passaic at Chatham	2,580	9	101
Pompton	9,700	37	418
Ramapo	4,100	14	186
Wanaque	2,800	9	117
Pequannock	2,200	7	99
Rockaway	3,400	19	157

a To be read one hundred sixty-seven thousand two hundred and twenty-five million gallons.

NAME OF STREAM.	YIELD IN MILLION GALLONS EACH 24 HOURS.		
	GREATEST.	LEAST.	AVERAGE.
Rockaway at Boonton	2,950	16	137
Whippany	1,800	10	72
Saddle river	1,500	6	62
Elizabeth river at Pennsylvania railroad	....	2	20
Rahway	2,000	8	85
Raritan	27,500	93	1,138
Raritan at New Brunswick	25,000	81	922
South river	2,100	16	167
Millstone	7,000	24	294
North Branch of Raritan	6,200	17	198
South Branch of Raritan	8,900	25	285
Swimming river at Red Bank	....	11	68
Manasquan inlet	....	....	84
Metedeconk at Burrsville	....	12	77
Metedeconk, north branch	....	7	45
Toms river	2,640	27	170
Mullica	7,000	96	593
Great Egg Harbor	4,400	57	351
Great Egg Harbor at Mays Landing	3,080	36	224
Maurice	5000	65	401
Maurice at Millville	3,100	37	227
Cohansey	1,350	18	98
Rancocas	4,500	58	335
Rancocas, north branch	1,860	24	142
Rancocas, south branch	2,150	28	164
Crosswicks	1,980	24	137

TIDE TABLE.

	High Water Later than Governor's Island.		Range of Tide in Feet.		
	Hours.	Minutes.	Mean.	Spring.	Neap.
The Battery, New York City	0	5	4.4	5.3	3.4
Jersey City Ferry, N. J	0	8	4.4	5.3	3.4
Pavonia Ferry, Twenty-third street, New York City	0	9	4.4	5.3	3.4
Weehawken, N. J	0	20	4.2	5.1	3.3
Ninety-sixth street, New York City	0	26	4.2	5.1	3.3
Edgewater, N. J	0	34	4.2	5.1	3.3
One Hundred and Thirty-first street, New York City	0	35	4.2	5.1	3.3
Fort Lee Pier South, N. J	0	37	4.1	5.0	3.2
Fort Washington Point, N. Y	0	38	4.1	5.0	3.2
Tubby Hook, N. Y	0	39	4.0	4.8	3.1
Spuyten Duyvil, N. Y	0	41	4.0	4.8	3.1
Huyler's Landing, N. J	0	56	3.9	4.7	3.0
Yonkers, N. Y	0	57	3.8	4.6	3.0
	High Water Later than Sandy Hook.				
	Hours.	Minutes.			
Elizabethport	0	57	4.6	5.6	3.6
Passaic light	1	12	4.7	5.7	3.7
Newark	1	32	5.0	6.0	3.9
New Brunswick, Raritan river	0	54	6.8	8.2	5.3
South Amboy	0	13	5.4	6.5	4.2
Keyport	0	10	5.6	6.8	4.4
Port Monmouth	0	5	4.8	5.8	3.7
Sandy Hook, Horseshoe	0	0	4.6	5.7	3.6
Seabright	0	15	4.0	4.8	3.1
Long Branch	0	10	4.4	5.3	3.4
Asbury Park	0	13	4.2	5.0	3.2
Sea Girt	0	15	4.0	4.8	3.1
	High Water Later than Barnegat Inlet.				
	Hours.	Minutes.			
Barnegat inlet	0	0	2.2	2.6	1.7
Kettle creek	4	49	0.6	0.7	0.4
Toms river	2	58	0.7	0.8	0.5
Cedar creek	1	29	1.0	1.2	0.8
Little Egg Harbor bay	1	31	2.3	2.8	1.8
Great bay	0	41	2.8	3.4	2.2

	High Water Later than Sandy Hook.		Range of Tide in Feet.		
	Hours.	Minutes.	Mean.	Spring.	Neap.
New inlet	0	19	3.5	4.2	2.7
Atlantic City	0	19	4.2	5.0	3.2
Absecon bay	2	31	3.9	4.7	3.0
Great Egg Harbor inlet	0	15	4.3	5.2	3.4
Corson inlet	0	13	4.3	5.2	3.4
Townsend inlet	0	10	4.2	5.0	3.2
Hereford inlet	0	7	4.3	5.2	3.4
Cold Spring inlet	0	5	4.4	5.3	3.4
Cape May	0	51	4.6	5.6	3.6
Marcy's Landing	1	9	5.0	6.0	3.9
Maurice River light	1	44	5.7	6.8	4.4
Egg Island light	1	39	6.0	7.2	4.6
Fortesque Beach	1	45	5.8	7.0	4.5
Ben Davis Point	2	0	6.3	7.6	4.9
	High Water Earlier than Philadelphia.				
	Hours.	Minutes.			
Cohansey light, N. J	4	4	6.5	7.5	5.4
Bombay Hook light, Del	3	25	6.1	7.1	5.1
Delaware City, Del	2	39	6.3	7.3	5.2
New Castle, Del	1	46	6.5	7.5	5.4
Christiana light, Del	1	45	6.2	7.2	5.1
Cherry Island light, Del	1	44	6.0	6.9	5.0
Marcus Hook, Pa	1	4	6.2	7.2	5.1
Chester, Pa	0	53	6.3	7.3	5.2
Billingsport, N. J	0	35	6.2	7.2	5.1
Fort Mifflin, Pa	0	31	6.1	7.1	5.1
Gibson Point, Schuylkill river, Pa	0	25	6.1	7.1	5.1
Wire Bridge, Schuylkill river, Pa	0	16	6.1	7.1	5.1
League Island Navy Yard, Pa	0	10	6.1	7.1	5.1
Gloucester, N. J	0	7	6.3	7.3	5.2
Philadelphia (Washington street), Pa	0	0	6.4	7.4	5.4
	High Water Later than Philadelphia.				
	Hours.	Minutes.			
Philadelphia (Walnut street), Pa	0	8	6.0	6.9	5.0
Camden (Cooper's Point), N. J	0	9	5.8	6.7	4.8
Philadelphia (Allegheny avenue), Pa	0	22	5.5	6.3	4.6
Bridesburg, Pa	0	28	5.2	6.1	4.3
Burlington, N. J	1	39	5.7	6.6	4.7
Bordentown, N. J	2	43	5.1	5.9	4.2
Trenton, N. J	3	8	4.1	4.8	3.4

The movement of the tidal wave, as shown by the above figures, is interesting. The whole distance from Governor's Island to Albany, up the Hudson river, amounting to 146 miles, is covered in 9 hours and 45 minutes, while up the Delaware, from the Capes to Trenton, 130 miles, is traversed by high water in 8 hours and 32 minutes. The rate for each river is very close to 15½ miles per hour, but this is a mere coincidence, as the rate up the Hudson is comparatively uniform, while up the Delaware there is a considerable variation. Thus, from Governor's Island to Rondout, a distance of 92 miles, the rate in Hudson river is very uniform at 20 miles per hour, as shown by several stations. From Rondout to Catskill, 21 miles, it is 12 miles per hour, and from Catskill to Albany, 33 miles, 10 miles per hour, showing a uniform decrease as the river becomes shoaler.

Up the Delaware the tidal wave travels from Cape May to Ben Davis Point, 30 miles, at the rate of 26 miles per hour. From Cohansey light to Delaware City, 21 miles, the rate is 15 miles per hour; from Delaware City to Christiana light, near Wilmington, the rate for 10 miles is 11 miles per hour; from Christiana light to Chester, 12 miles, it is 14 miles per hour, while from Chester to Philadelphia, 16 miles, it is 16 miles per hour. From Philadelphia to Burlington, 21 miles, the rate is 14 miles per hour, while from Burlington to Trenton, 14 miles, it is 10 miles per hour. The tide moves up Raritan river from Amboy to New Brunswick, 12 miles, at the rate of 18 miles per hour; from Elizabethport, up Newark bay, to Passaic light, it is 18 miles per hour, and from Passaic light, up Passaic river, to Newark, 18 miles per hour.

In Barnegat bay high water travels from Barnegat inlet up to Kettle creek, near the head of the bay, a distance of 19 miles, at the rate of 4 miles per hour. From the inlet to Toms river, 16 miles, the rate is 5 miles per hour, while from the inlet to Cedar creek, 9 miles, it is 6 miles per hour. The depth of water in the bay is about 5 feet average. In general the rate varies with the depth, other things being equal.

POLITICAL DIVISIONS AND AREAS.

East and West New Jersey.

The earliest division of New Jersey was into East and West Jersey. Charles II. granted New England and the country westward to the Delaware river to James, Duke of York, March 12th, 1663–64. The Duke of York transferred New Jersey to John, Lord Berkeley, and Sir George Carteret the following 24th day of June. They held and governed it until the 29th of July, 1674, when the Duke of York, in a second grant, deeded to Carteret all of the province north of a line drawn from "a certain creek called Barnegatt, being about the middle between Sandy Point and Cape May, * * * to a certain creek in Delaware river, next adjoining to and below a certain creek in Delaware river called Renkokus Kill." * The division into East and West Jersey, however, was finally made by the Quintipartite Deed of July 1st, 1676, "between Sir George Carteret, of Saltreene, in the county of Devon, knight and baronet, and one of his Majesty's most honorable Privy Council, of the first part; William Penn, of Richman's worth, in the county of Hertford, Esq., of the second part; Gawn Lawry of London, merchant, of the third part; Nicholas Lucas of Hertford, in the county of Hertford, malster, of the fourth part; and Edward Billinge of Wistminster, in the county of Middlesex, gent., of the fifth part." †

The last four parties held the undivided moiety or half part which had been transferred by Lord Berkeley. No mention is here made of the second grant of the Duke of York to Carteret. This quintipartite deed gives to Carteret all east of a straight line to be drawn from the most northerly point of the Duke of York's grant, here agreed to be called the north partition point, "unto the most southwardly point of the east side of Little Egg Harbour," which was agreed to be called the south partition point. His part was to be known as East New Jersey and the part west of this line was deeded to the other four parties, and was to be known as West New Jersey. The uncertainty as to what point on the Delaware was intended by the Duke of York to be the northernmost point led, to disputes as to the north line of the province, which were finally

* Leaming & Spicer, p. 47.

† Id., p. 61.

settled by the commission of 1767 agreeing upon the forks of the Mahackamack or Navesink river as the point, so there were controversies as to this line, which were settled by the adoption of Lawrence's line, run in 1743, but in this case the northernmost point was taken to be at Cochecton, in latitude 41 deg. 40 min. A line had been run in 1687, by George Keith, however, which, although it was not accepted by the proprietors, was agreed on as the line by Governor Daniel Coxe, of West Jersey, and Governort Robert Barclay, of East Jersey, in 1688. While this agreement had no effect on the claims of the respective proprietors, it did give this line prominence as a political division, and it is to-day represented in the boundaries of ten counties. It ran from the north side of Little Egg Harbor inlet in a straight line to where the present line between Hunterdon and Somerset counties strikes the South Branch of the Raritan river, at Three Bridges; thence along the present line between said counties to Lamington river (this line then following the rear of the plantations along the Raritan); thence up said river to Allamatonk falls; thence straight to the nearest point of the Passaic river, as the line between Somerset and Morris counties now runs. From here it followed down the Passaic and up the Pequannock to latitude 41 degrees, thence due east to the partition point between New Jersey and New York, on Hudson river. The whole area of the State, excluding the waters of Raritan and Delaware bays, being 7,795 square miles, this division would have given East Jersey but 2,392 square miles and West Jersey 5,403 square miles. The line finally adopted was run by John Lawrence, in 1743, as nearly straight as the rough compass and chain survey of that time would admit of, from the north side of Little Egg Harbor inlet to Cochecton, crossing the Delaware river about one and one-half miles below Dingman's Ferry. This gave to East Jersey 3,073 square miles and to West Jersey 4,722 square miles. This line has only been preserved as a political division in the boundaries of six townships of Sussex county. The governments of East and West Jersey having been surrendered in 1702, and the two divisions united under one government, this became merely a property line.

The Formation of Counties.

Under the government of the proprietors of East Jersey a law was passed by the General Assembly in 1682, creating the four counties of Bergen, Essex, Middlesex and Monmouth.* In 1688 Somerset county was formed from a part of Middlesex.†

In West Jersey, Cape May county was erected in 1685.‡ This act states that the province had formerly been divided into three counties, but they could not have been very well defined. In 1692 the bounds between Burlington and Gloucester were defined, § but this law was repealed the following year, and the boundary must have been left quite indefinite.

In 1694 laws were passed fixing the boundaries of Burlington, Gloucester and Salem counties a few miles back from Delaware river only, leaving everything indefinite in the interior.

In 1709 an act was passed defining the boundaries of all the counties in the province of New Jersey. The counties named in this act were Bergen, Essex, Somerset, Middlesex, Monmouth, Burlington, Gloucester, Salem and Cape May. Most of the lines then established still remain county lines.

In 1713 all of the northern part of the province not contained in the above-mentioned counties was erected into the county of Hunterdon. From this time the several counties began to assume their present shape. Hunterdon was reduced to its present form by the setting off of Morris county, in 1738–9. Somerset and Middlesex have been but little changed since 1713–14, and in the same year Monmouth was made to include what is now Monmouth and Ocean counties. Cumberland was set off from Salem in 1748, the latter county remaining otherwise as created in 1709. Sussex county was formed, containing what is now Sussex and Warren, in 1753. Warren was erected in 1824, Passaic and Atlantic in 1837, Mercer in 1838, Hudson in 1840, Camden in 1844, from Gloucester; Ocean in 1850, from Monmouth; Union in 1857, from Essex. There are at present twenty-one counties.

The General Assembly of East Jersey, in 1693, passed a law dividing the several counties into townships, as follows: || Bergen into Hacksack and Bergen; Essex into Acquickanick and New Barbadoes, Newark and Elizabethtown; Middlesex into Woodbridge, Perth

* Leaming & Spicer, p. 229.

† Id., p. 305. ‡ Id., p. 507. § Id., p. 513. || Id., p. 328.

Amboy and Piscataway; Monmouth into Middletown, Shrewsbury and Freehold. Somerset was not subdivided. We have few records of the erection of townships in West Jersey, but an act of 1701 * mentions in Burlington county, Hopewell, Maidenhead, Nottingham, Chesterfield, Mansfield, Springfield, Northampton, Burlington, Wellinborough, Chester, Eversham; in Gloucester county, Waterford, Newton, Gloucester, Deptford, Greenwich, Egg Harbour; in Salem county, the precincts of Salem, Elsinborough, Penn's Neck, Maneton (Mannington), Alloways Creek, "the upper side of Cohansey creek," and Fairfield. None are mentioned in Cape May county. From this beginning the number of townships has steadily increased, until now it has reached 247. These townships range in size from 136 square miles, the area of Galloway township, Atlantic county, to less than one square mile.

Areas.

The following table of areas has been prepared from the maps of the Topographic Survey, as follows: The State was divided into sections, including 15 minutes of latitude by 15 minutes of longitude, or one-sixteenth of a square degree each. The areas of these sections were determined geodetically; all sections having the same latitudes being, of course, equal in area. Then to ascertain the area of the State, all of those sections lying partly within and partly without the State had these two parts carefully measured with an Amstler polar planimeter. The sum of these areas, or the whole area of the section as ascertained by planimetric measurement, was then compared with the geodetic area, and the small difference indicated was divided proportionally between the two parts. Then the sum of all the sections and part sections lying within the State boundaries, gave the true area of the State.

The boundaries followed in the measurement are shown on the map of New Jersey, on a scale of five miles to an inch, and are also given in the chapter on boundaries. Seaward they included all to a line drawn across from Oriental Hotel station, United States Coast and Geodetic Survey, on Coney Island, to Hook beacon on Sandy Hook; thence following low-water mark to Cape May, crossing the several inlets on a line with the beach fronts; thence straight across toward Cape Henlopen to the intersection of the Delaware and New Jersey

* Leaming & Spicer, p. 581.

line through the middle of the bay. The areas of the counties were then determined by measuring the part sections lying in the several counties, correcting these partial areas so that their sum in each section agreed with the true geodetic area of the section, and then adding together the areas belonging to each county. The townships were next measured, and the sum of the areas of those in a given county made to agree with the area of the county as already ascertained.

By this system of measurement it is believed that the list of areas here given is freed from all errors save those which come from uncertainty as to the exact location of boundary lines, arising from vagueness of description or imperfect marking.

Summary of Areas.

	Square Miles.	Acres.
The State	8,224.44	5,263,641
Land surface	7,514.40	4,809,218
Water surface*	710.04	454,423
Upland †	7,022.76	4,494,567
Tide-marsh ‡	462.95	296,289
Beach	28.36	18,151
Forest §	3,234.09	2,069,819
Cleared upland	3,788.67	2,424,748
Improved land in farms, census of 1880 ‖	....	2,096,297

* Includes all streams and channels more than 100 yards in width, and all bodies of water approximating or exceeding 100 acres in extent.

† Upland as distinguished from tide-marsh, but really including all swamps and fresh meadow.

‡ 34,304 acres of this is embanked and more or less improved.

§ Includes all lots of ten acres and upward.

‖ A comparison of the areas by counties in the census with the areas below, will show, in most cases, a considerable excess of cleared upland over improved land in farms. Cape May and Cumberland counties are exception but here and in Camden, Gloucester and Salem counties, considerable areas of improved tide-marsh have been included in the improved land in farms. For the State the areas of cleared upland and improved tide-marsh aggregate 2,459,052 acres, exceeding the census figures for improved land in farms by 362,755 acres. This excess may be accounted for approximately as follows:

Cleared but unimproved land in farms	125,384	acres.
Highways	150,000	"
City and town sites	65,000	"
Railway lines	20,000	"

This is sufficiently close to establish the accuracy of the census figures. The agreement of the two sets of figures obtained by entirely independent and widely different methods, is in fact remarkable.

Areas by Counties.

COUNTIES.	Total.		Upland.	Tide Marsh.	Beach.	Total Land Surface.	Water.	Cleared Upland.	Forest.
	Sq. M.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.
Atlantic	613.49	392,633	307,409	53,325	3,415	364,149	28,484	35,771	271,638
Bergen...............	246.17	157,547	143,470	8,378	....	151,848	5,699	85,879	57,591
Burlington.........	823.49	527,028	511,756	9,943	....	521,699	5,329	207,979	303,777
Camden	225.96	144,613	139,101	2,964	....	142,065	2,548	72,513	66,588
Cape May...........	450.91	288,585	110,674	53,638	5,503	169,815	....	....	....
Cumberland	674.28	431,541	267,580	52,661	....	320,241	111,300	101,316	166,264
Essex	129 72	83,023	76,746	4,631	....	81,377	1,646	52,507	24,239
Gloucester.........	341.45	218,528	201,503	10,735	....	212,236	6,292	125,685	74,818
Hudson.............	60.48	38,709	15,786	11,468	....	27,254	11,455	15,073	713
Hunterdon	439.12	281,037	279,919	....	....	279,919	1,118	240,438	39,481
Mercer...............	227.90	145,858	144,229	376	....	144,605	1,253	128,400	15,829
Middlesex.........	324.44	207,639	191,440	8,199	....	199,639	8,000	131,276	60,164
Monmouth........	537.94	344,280	300,999	3,378	1,901	306,278	38,002	211,288	89,711
Morris...............	480.19	307,318	303,910	....	....	303,910	3,408	163,809	140,101
Ocean................	750.91	480,584	360,171	40,400	7,332	407,903	72,681	47,084	313,087
Passaic	198.65	127,134	125,488	....	....	125,488	1,646	50,284	75,204
Salem.................	389.37	249,198	188,138	31,780	....	219,918	29,280	138,081	50,057
Somerset	305.02	195,213	194,965	....	....	194,965	248	166,352	28,613
Sussex	535.81	342,603	338,393	....	....	338,393	4,210	201,855	136,538
Union	104.94	67,164	61,304	4,413	....	65,717	1,447	46,954	14,850
Warren	364.65	233,376	231,769	....	....	231,769	1,607	171,564	60,205
The State...........	8224.44	5,263,641	4,494,567	296,289	18,151	4,809,218	454,423	2,424,748	2,069,819

Atlantic County.

Townships.	Total. Sq. M.	Total. Acres.	Upland. Acres.	Tide Marsh. Acres.	Water. Acres.	Beach. Acres.	Cleared Upland. Acres.	Forest. Acres.
Absecon	5.299	3,391	2,396	995	....	....	1,066	1,330
Atlantic City	2.620	1,677	....	720	166	791	....	....
Buena Vista	57.974	37,103	37,103	....	....	....	4,940	32,163
Egg Harbor	111.678	71,474	43,300	18,387	8,703	1,084	9,266	34,034
Egg Harbor City	10.624	6,799	5,971	643	185	....	659	5,312
Galloway	135.949	87,008	44,074	23,660	17,734	1,540	6,873	37,201
Hamilton	113.857	72,869	72,690	....	179	....	1,197	71,493
Hammonton	45.008	28,805	28,805	....	....	....	7,142	21,663
Mullica	54.818	35,083	35,083	....	....	....	2,266	32,817
Weymouth	75.663	48,424	37,987	8,920	1,517	....	2,362	35,625
Totals	613.490	392,633	307,409	53,325	28,484	3,415	35,771	271,638

Bergen County.

Townships.	Total. Sq. M.	Total. Acres.	Upland. Acres.	Tide Marsh. Acres.	Water. Acres.	Cleared Upland. Acres.	Forest. Acres.
Bergen	7.410	4,742	3,078	1,664	123	1,291	978
Boiling Springs	3.930	2,515	902	1,523	90	486	416
Englewood	7.314	4,681	3,984	....	697	2,113	1,871
Franklin	28.081	17,972	17,972	....	....	10,122	7,850
Harrington	26.764	17,129	15,537	....	1,592	6,995	8,542
Hohokus	32.714	20,937	20,937	....	....	8,718	12,219
Lodi	7.667	4,907	4,596	261	50	3,352	1,244
Midland	16.035	10,262	10,262	....	....	7,229	3,033
New Barbadoes	3.857	2,468	2,033	345	90	1,778	255
Orvil	17.260	11,046	11,046	....	....	7,265	3,781
Palisade	16.409	10,502	9,632	....	870	5,322	4,310
Ridgefield	16.160	10,342	6,818	1,714	1,810	4,511	2,307
Ridgewood	6.921	4,429	4,429	....	....	3,277	1,152
Saddle River	14.883	9,525	9,525	....	....	7,265	2,260
Teaneck	6.300	4,032	3,661	371	....	3,053	608
Union	10.065	6,442	3,565	2,500	377	1,746	719
Washington	24.398	15,616	15,616	....	....	9,565	6,051
Totals	246.168	157,547	148,470	8,378	5,699	85,879	57,591

Burlington County.

TOWNSHIPS.	Total.		Upland.	Tide Marsh.	Water.	Cleared Upland.	Forest.
	Sq. M.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.
Bass River	79.623	50,959	44,834	5,166	959	1,573	43,261
Beverly City	0.544	348	348	....	....	348	....
Beverly Township	6.250	4,000	3,182	109	709	2,971	211
Bordentown	9.140	5,850	5,536	83	231	5,130	406
†Burlington	18.830	12,051	10,862	397	792	9,923	939
Chester	18.904	12,099	11,977	122	....	11,059	918
Chesterfield	22.123	14,159	14,159	....	....	13,827	332
Cinnaminson	8.980	5,747	4,894	247	606	4,600	294
Delran	5.770	3,690	3,420	190	80	2,722	698
Easthampton	5.766	3,690	3,690	....	....	3,600	90
Evesham	29.604	18,947	18,947	....	....	10,012	8,935
Florence	10.153	6,498	6,076	45	377	5,776	300
Lumberton	20.380	13,045	13,045	....	....	11,432	1,613
Mansfield	23.204	14,851	14,518	96	237	13,635	883
Medford	42.001	26,880	26,880	....	....	9,622	17,258
Mount Laurel	22.128	14,162	14,162	....	....	12,996	1,166
New Hanover	40.913	26,184	26,184	....	....	18,912	7,272
Northampton	2.796	1,788	1,788	....	....	1,642	146
Palmyra	2.630	1,683	787	474	422	755	32
Pemberton	64.899	41,535	41,535	....	....	12,913	28,622
Riverside	3.280	2,102	1,510	250	342	1,190	320
Shamong	70.321	45,005	45,005	....	....	7,852	37,153
Southampton	47.194	30,204	30,204	....	....	14,581	15,623
Springfield	29.576	18,929	18,929	....	....	18,372	557
Washington	103.200	66,048	62,430	....	....	1,777	60,653
Westhampton	11.242	7,195	7,195	....	....	6,287	908
Willingboro	7.238	4,632	4,543	89	....	3,700	843
Woodland	116.792	74,747	74,747	....	....	403	74,344
Totals	823.481	527,028	511,756	*9,943	5,329	207,979	303,777

† Includes Burlington city. * 299 acres of this is embanked and improved.

Camden County.

TOWNSHIPS.	Total. Sq. M.	Total. Acres.	Upland. Acres.	Tide Marsh. Acres.	Water. Acres.	Cleared Upland. Acres.	Forest. Acres.
Camden City	5.241	3,354	1,971	561	822	1,971	....
Centre	12.995	8,317	7,845	472	....	6,883	962
Delaware	24.395	15,613	15,613	....	....	13,734	1,879
Gloucester	36.667	23,467	23,467	....	....	15,215	8,252
Gloucester City	1.732	1,108	535	223	350	535	....
Haddon	12.344	7,900	7,314	586	....	7,186	128
Merchantville	0.632	404	404	....	....	369	35
Pensauken	12.294	7,868	5,920	732	1,216	5,639	281
Stockton	3.100	1,984	1,434	390	160	1,434	....
Waterford	57.325	36,688	36,688	....	....	10,023	26,665
Winslow	59.233	37,910	37,910	....	....	9,524	28,386
Totals	225.958	144,613	139,101	2,964	2,548	72,513	66,588

Cape May County.

TOWNSHIPS.	Total. Sq. M.	Total. Acres.	Upland. Acres.	Tide Marsh. Acres.	Water. Acres.	Beach. Acres.	Cleared Upland. Acres.	Forest. Acres.
Cape May City	2.056	1,316	177	920	58	161	177	....
Dennis	76.904	49,218	37,525	9,994	1,113	586	6,370	31,155
Lower	35.641	22,810	13,634	7,238	1,210	738	6,924	6,710
Middle	93.057	59,556	29,619	21,321	6,184	2,432	10,515	19,104
Upper	79.316	50,763	29,719	14,170	5,283	1,591	5,837	23,882
*Water	163.937	104,922	....	....	104,922	....	....	....
Totals	450.911	288.585	110,674	†53,638	118,770	5,508	29,823	80,851

*Part of Delaware bay included in Cape May county, but not belonging to any township.
†1,402 acres of this is embanked and more or less improved.

Cumberland County.

Townships.	Total.		Upland.	Tide Marsh.	Water.	Cleared Upland.	Forest.
	Sq. M.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.
Bridgeton	6.760	4,326	4,326	....	....	3,884	442
Commercial	35.096	22,461	13,954	7,765	742	4,907	9,047
Deerfield	47.456	30,372	30,372	....	....	16,653	13,719
Downe	57.023	36,495	20,374	15,666	455	4,228	16,146
Fairfield	44.565	28,522	19,086	8,764	672	8,673	10,413
Greenwich	19.361	12,391	8,015	4,139	237	6,313	1,702
Hopewell	31.496	20,157	18,276	1,516	365	16,105	2,171
Landis	67.776	43,376	43,376	....	....	15,981	27,395
Lawrence	36.093	23,100	17,374	5,585	141	6,284	11,090
Maurice River	95.977	61,426	52,904	7,818	704	5,322	47,582
Millville	45.529	29,138	28,217	563	358	3,876	24,341
Stow Creek	19.271	12,333	11,405	845	83	9,289	2,116
*Water	167.927	107,478	....	....	107,478	....	....
Totals	674.330	431,541	267,580	†52,661	111,300	101,316	166,264

* Part of Delaware bay included in Cumberland county, but not belonging to any township.
† 7,142 acres of this is embanked and improved.

Essex County.

Townships.	Total.		Upland.	Tide Marsh.	Water.	Cleared Upland.	Forest.
	Sq. M.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.
Belleville	2.926	1,873	1,822	....	51	1,428	394
Bloomfield	6.732	4,308	4,308	....	....	3,574	734
Caldwell	21.068	13,484	13,484	....	....	8,303	5,181
Clinton	6.870	4,397	3,769	628	....	3,663	106
East Orange	3.903	2,498	2,498	....	....	2,338	160
Franklin	3.492	2,235	2,197	....	38	1,838	359
Livingston	17.419	11,148	11,148	....	....	6,123	5,025
Millburn	10.194	6,524	6,524	....	....	3,619	2,905
Montclair	6.180	3,955	3,955	....	....	3,081	874

Essex County—Continued.

Townships.	Total.		Upland.	Tide Marsh.	Water.	Cleared Upland.	Forest.
	Sq. M.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.
Newark	21.034	13,462	7,902	4,003	1,557	7,455	447
Orange	2.144	1,372	1,372	....	....	1,332	40
South Orange	8.327	5,329	5,329	....	....	3,901	1,428
Verona	7.360	4,710	4,710	....	....	2,278	2,432
West Orange	12.075	7,728	7,728	....	....	3,574	4,154
Totals	129.724	83,023	76,746	4,631	1,646	52,507	24,239

Gloucester County.

Townships.	Total.		Upland.	Tide Marsh.	Water.	Cleared Upland.	Forest.
	Sq. M.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.
Clayton	8.161	5,223	5,223	....	....	2,615	2,608
Deptford	20.362	13,032	12,623	409	....	9,631	2,992
East Greenwich	14.190	9,082	9,024	58	....	7,715	1,309
Elk	23.830	15,251	15,251	....	....	9,721	5,530
Franklin	60.045	38,429	34,829	....	....	8,062	26,767
Glassboro	7.340	4,698	4,698	....	....	2,836	1,862
Greenwich	14.959	9,574	4,318	3,378	1,878	4,177	141
Harrison	16.565	10,601	10,601	....	....	9,718	883
Logan	28.101	17,984	10,863	4,502	2,619	8,801	2,062
Mantua	18.869	12,076	12,076	....	....	10,091	1,985
Monroe	45.837	29,335	29,335	....	....	7,824	21,511
South Harrison	16.812	10,760	10,760	....	....	8,630	2,130
Washington	22.575	14,448	14,448	....	....	10,584	3,864
West Deptford	20.172	12,910	9,167	1,948	1,795	8,344	823
Woodbury	1.687	1,080	1,029	51	....	1,023	6
Woolwich	21.945	14,045	13,656	389	....	13,311	345
Totals	341.450	218,528	201,503	*10,735	6,292	126,685	74,818

* 3,558 acres of this is embanked and improved.

Hudson County.

Townships.	Total.		Upland.	Tide Marsh.	Water.	Cleared Upland.	Forest.
	Sq. M.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.
Bayonne	11.583	7,381	2,279	404	4,698	2,279	....
Guttenberg	0.208	183	183	....	....	183	....
Harrison	1.309	838	534	246	58	534	....
Hoboken	1.907	1,220	518	209	493	518	....
Jersey City	19.199	12,288	5,859	2,086	4,343	5,836	23
Kearny	10.283	6,581	1,448	4,520	613	1,208	240
North Bergen	11.949	7,647	3,152	3,990	505	2,788	364
Union (Town of)	0.425	272	272	....	....	272	....
Union Township	1.329	851	592	....	259	582	10
Weehawken	1.472	942	448	13	486	367	76
West Hoboken	0.869	556	556	....	....	556	....
Totals	60.483	38,709	15,786	*11,468	11,455	15,073	713

* 4,045 acres of this is embanked.

Hunterdon County.

Townships.	Total.		Land.	Water.	Cleared Land.	Forest.
	Sq. M.	Acres.	Acres.	Acres.	Acres.	Acres.
Alexandria	27.381	17,524	17,454	70	15,097	2,357
Bethlehem	23.645	15,133	15,133	....	9,789	5,344
Clinton (Town of)	1.128	722	722	....	722	....
Clinton Township	28.010	17,926	17,926	....	16,023	1,903
Delaware	43.107	27,589	27,353	236	25,028	2,325
East Amwell	24.577	15,729	15,729	....	12,313	3,416
Franklin	22.861	14,631	14,631	....	13,334	1,297
Frenchtown	0.439	281	236	45	236	....
High Bridge	17.731	11,348	11,348	....	8,481	2,867
Holland	24.886	15,927	15,665	262	12,594	3,071
Kingwood	36.940	23,642	23,271	371	20,698	2,573

Hunterdon County—Continued.

TOWNSHIPS.	Total.		Land.	Water.	Cleared Land.	Forest.
	Sq. M.	Acres.	Acres.	Acres.	Acres.	Acres.
Lambertville	1.178	754	671	83	671	....
Lebanon	26.396	16,893	16,893	....	12,313	4,580
Raritan	39.663	25,384	25,384	....	24,050	1,334
Readington	48.734	31,190	31,190	....	29,818	1,372
Tewksbury	32.281	20,660	20,660	....	16,792	3,868
Union	19.897	12,734	12,734	....	11,910	824
West Amwell	20.266	12,970	12,919	51	10,569	2,350
Totals	439.120	281,037	279,919	1,118	240,438	39,481

Mercer County.

TOWNSHIPS.	Total.		Upland.	Tide Marsh.	Water.	Cleared Upland.	Forest.
	Sq. M.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.
East Windsor	16.956	10,852	10,852	....	....	9,104	1,748
Ewing	17.748	11,359	11,103	....	256	10,512	591
Hamilton	41.075	26,288	25,388	376	524	23,432	1,956
Hopewell	60.242	38,555	38,312	....	243	34,893	3,419
Lawrence	21.660	13,862	13,862	....	....	12,902	960
Princeton	18.331	11,732	11,732	....	....	9,951	1,781
Trenton	4.761	3,047	2,817	....	230	2,817	....
Washington	20.796	13,309	13,309	....	....	10,982	2,327
West Windsor	26.334	16,854	16,854	....	....	13,807	3,047
Totals	227.903	145,858	144,229	376	1,253	128,400	15,829

Middlesex County.

TOWNSHIPS.	Total.		Upland.	Tide Marsh.	Water.	Cleared Upland.	Forest.
	Sq. M.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.
Cranbury	17.718	11,886	11,886	....	....	9,886	1,450
East Brunswick	29.162	18,664	17,971	622	71	9,745	8,226
Madison	37.496	23,998	22,766	1,232	....	9,136	13,630
Monroe	44.159	28,262	28,262	....	....	21,025	7,237
New Brunswick	4.351	2,785	2,586	51	148	2,528	58
North Brunswick	14.024	8,975	8,975	....	....	7,076	1,899
Perth Amboy	6.245	3,997	2,624	334	1,039	1,880	744
Piscataway	32.212	20,616	20,462	....	154	19,107	1,355
Raritan	35.688	22,840	20,370	1,950	520	15,038	5,332
Sayreville	16.983	10,869	8,297	1,700	872	1,871	6,416
South Amboy	1.300	832	774	58	....	524	250
South Brunswick	48.971	31,341	31,341	....	....	21,640	9,701
Woodbridge	29.536	18,903	15,676	2,252	975	11,810	3,866
*Water	6.596	4,221	....	....	4,221	....	....
Totals	324.436	207,639	191,440	8,199	8,000	131,276	60,164

*Part of Raritan bay included in Middlesex county, but not belonging to any township.

Monmouth County.

TOWNSHIPS.	Total.		Upland.	Tide Marsh.	Water.	Beach.	Cleared Upland.	Forest.
	Sq. M.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.
Atlantic	31.662	20,264	20,264	....	....	....	14,088	6,176
Eatontown	12.000	7,680	7,199	77	404	....	5,358	1,841
Freehold	40.577	25,969	25,969	....	....	....	16,941	9,028
Holmdel	17.968	11,500	11,500	....	....	....	10,203	1,297
Howell	65.951	42,209	42,209	....	....	....	16,345	25,864
Manalapan	31.276	20,017	20,017	....	....	....	16,755	3,262
Marlboro	30.575	19,568	19,568	....	....	....	14,860	4,708
Matawan	8.455	5,411	4,891	520	....	....	4,304	587
Middletown	43.132	27,604	25,326	1,008	1,270	....	20,853	4,973
Millstone	39.616	25,354	25,354	....	....	....	19,300	6,054

Monmouth County—Continued.

Townships.	Total.		Upland.	Tide Marsh.	Water.	Beach.	Cleared Upland.	Forest.
	Sq. M.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.
Neptune	12.756	8,164	7,445	39	680	....	3,553	3,892
Ocean	25.237	16,152	12,855	206	1,690	1,901	9,450	2,905
Raritan	9.410	6,022	5,200	822	....	....	4,169	1,031
Shrewsbury	32.882	21,044	18,308	526	2,210	....	13,055	5,253
Upper Freehold	47.997	30,718	30,718	....	....	....	29,550	1,168
Wall	40.994	26,236	24,676	180	1,380	....	13,004	11,672
*Water	47.450	30,368	....	....	30,368	....	....	....
Totals	587.938	344,280	300,999	3,378	38,002	1,901	211,288	89,711

*Part of Raritan bay included in Monmouth county, but not belonging to any township.

Morris County.

Townships.	Total.		Land.	Water.	Cleared Land.	Forest.
	Sq. M.	Acres.	Acres.	Acres.	Acres.	Acres.
Boonton	8.705	5,571	5,571	....	2,265	3,306
Chatham	22.913	14,664	14,664	....	10,611	4,053
Chester	30.200	19,328	19,328	....	13,089	6,239
Hanover	49.757	31,845	31,845	....	21,453	10,392
Jefferson	44.258	28,325	27,815	1,010	7,869	19,946
Mendham	24.355	15,587	15,587	....	10,969	4,618
Montville	18.850	12,064	12,064	....	6,490	5,574
Morris	15.980	10,227	10,227	....	6,752	3,475
Morristown	2.890	1,850	1,850	....	1,517	333
Mount Olive	32.066	20,522	20,036	486	11,282	8,754
Passaic	33.315	21,322	21,322	....	16,160	5,162
Pequannock	36.777	23,537	23,430	107	9,370	14,060
Randolph	27.854	17,827	17,827	....	9,607	8,220
Rockaway	63.339	40,537	39,420	1,117	10,606	28,814
Roxbury	24.244	15,516	14,828	688	7,012	7,816
Washington	44.682	28,596	28,596	....	19,257	9,339
Totals	480.185	307,318	303,910	3,408	163,809	140,101

Ocean County.

Townships.	Total.		Upland.	Tide Marsh.	Water.	Beach.	Cleared Upland.	Forest.
	Sq. M.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.
Berkeley	58.568	37,480	26,826	2,036	7,615	1,003	2,091	24,735
Brick	38.507	24,554	17,681	2,739	3,787	347	4,081	13,600
Dover	55.732	35,669	24,534	2,458	7,785	892	6,494	18,040
Eagleswood	35.308	22,597	6,251	5,566	9,607	1,173	1,036	5,215
Jackson	98.431	62,996	62,996	....	....	....	9,873	53,123
Lacey	107.511	68,807	56,369	2,800	8,792	846	2,621	53,748
Lakewood	23.620	15,117	15,117	....	....	....	2,285	12,832
Little Egg Harbor	75.305	48,195	21,173	12,431	13,602	989	3,253	17,920
Manchester	83.239	53,273	53,273	....	....	....	1,857	51,416
Ocean	33.936	21,719	10,182	1,368	9,569	600	972	9,210
Plumstead	40.191	25,722	25,722	....	....	....	8,245	17,477
Stafford	55.749	35,679	22,803	6,246	5,756	874	2,800	20,003
Union	44.821	28,686	17,154	4,756	6,168	608	1,386	15,768
Totals	750.918	430,584	360,171	40,400	72,681	7,332	47,084	308,087

Passaic County.

Townships.	Total.		Land.	Water.	Cleared Land.	Forest.
	Sq. M.	Acres.	Acres.	Acres.	Acres.	Acres.
Acquackanonck	11.338	7,256	7,256	....	6,395	861
Little Falls	5.804	3,715	3,715	....	2,509	1,206
Manchester	10.934	6,998	6,998	....	4,556	2,442
Passaic	3.241	2,074	2,074	....	2,023	51
Paterson	8.472	5,422	5,422	....	5,131	291
Pompton	51.884	33,206	33,002	204	7,535	25,467
Wayne	26.729	17,107	17,011	96	9,488	7,523
West Milford	80.244	51,356	50,010	1,346	12,647	37,363
Totals	198.646	127,134	125,488	1,646	50,284	75,204

Salem County.

TOWNSHIPS.	Total.		Upland.	Tide Marsh.	Water.	Cleared Upland.	Forest.
	Sq. M.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.
Alloway	34.046	21,789	21,789	....	....	14,032	7,757
Elsinboro	13.242	8,475	4,261	4,163	51	4,188	73
Lower Alloways Creek	45.787	29,304	13,462	15,759	83	10,731	2,731
Lower Penns Neck	24.075	15,408	10,787	4,218	403	10,187	600
Mannington	38.321	24,526	20,204	4,047	275	18,551	1,653
Oldmans	21.266	13,610	11,216	1,710	684	8,414	2,802
Pilesgrove	37.044	23,708	23,708	....	....	22,414	1,294
Pittsgrove	50.014	32,009	32,009	....	....	11,165	20,844
Quinton	24.798	15,871	15,373	498	....	8,101	7,272
Salem	2.868	1,832	1,258	523	51	1,258	....
Upper Penns Neck	18.707	11,973	11,111	862	....	8,663	2,448
Upper Pittsgrove	35.876	22,960	22,960	....	....	20,377	2,583
*Water	43.383	27,783	....	....	27,783	....	....
Totals	389.372	249,198	188,188	†31,780	29,230	138,081	50,057

* Part of Delaware river included in Salem county, but not belonging to any township.
† 15,225 acres of this is embanked and improved.

Somerset County.

TOWNSHIPS.	Total.		Land.	Water.	Cleared Land.	Forest.
	Sq. M.	Acres.	Acres.	Acres.	Acres.	Acres.
Bedminster	27.018	17,292	17,292	....	16,882	410
Bernards	41.402	26,497	26,497	....	20,435	6,062
Branchburg	20.862	13,032	13,032	....	12,867	165
Bridgewater	44.395	28,413	28,343	70	23,729	4,614
Franklin	47.107	30,148	29,970	178	27,477	2,493
Hillsboro	58.232	37,268	37,268	....	33,226	4,042
Montgomery	33.075	21,168	21,168	....	20,074	1,094
North Plainfield	14.051	8,993	8,993	....	4,598	4,395
Warren	19.378	12,402	12,402	....	7,064	5,338
Totals	305.020	195,213	194,965	248	166,352	28,618

Sussex County.

Townships.	Total.		Land.	Water.	Cleared Land.	Forest.
	Sq. M.	Acres.	Acres.	Acres.	Acres.	Acres.
Andover	24.599	15,743	15,626	117	10,903	4,723
Byram	36.249	23,199	21,912	1,287	4,948	16,964
Frankford	36.509	23,366	22,581	785	16,617	5,964
Green	20.969	13,420	13,420	....	10,609	2,811
Hampton	29.765	19,050	18,950	100	14,254	4,696
Hardyston	38.741	24,794	24,794	....	13,438	11,356
Lafayette	18.245	11,677	11,677	....	10,346	1,331
Montague	44.565	28,522	28,166	356	9,319	18,847
Newton	2.750	1,760	1,760	....	1,587	173
Sandyston	42.527	27,217	27,002	215	12,821	14,181
Sparta	42.233	27,029	26,893	136	14,293	12,600
Stillwater	37.614	24,073	23,473	600	17,223	6,250
Vernon	69.045	44,189	43,949	240	20,292	23,657
Wallpack	23.337	14,936	14,562	374	7,122	7,440
Wantage	68.169	43,628	43,628	....	38,083	5,545
Totals	535.317	342,603	338,393	4,210	201,855	136,538

Union County.

Townships.	Total.		Upland.	Tide Marsh.	Water.	Cleared Upland.	Forest.
	Sq. M.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.
Clark	4.743	3,036	3,036	....	....	2,806	230
Cranford	5.838	3,736	3,736	....	....	2,727	1,009
Elizabeth	12.961	8,295	4,388	2,658	1,249	3,989	399
Fanwood	10.451	6,689	6,689	....	....	4,668	2,021
Linden	14.008	8,965	7,057	1,710	198	5,822	1,235
New Providence	9.919	6,348	6,348	....	....	3,703	2,645
Plainfield	5.923	3,791	3,791	....	....	3,433	358
Rahway	4.035	2,582	2,537	45	....	2,484	53
Springfield	4.958	3,173	3,173	....	....	1,966	1,207

Union County—Continued.

TOWNSHIPS.	Total.		Upland.	Tide Marsh.	Water.	Cleared Upland.	Forest.
	Sq. M.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.
Summit	6.012	3,848	3,848	....	....	2,222	1,626
Union	15.274	9,775	9,775	....	....	8,812	1,463
Westfield	10.822	6,926	6,926	....	....	4,822	2,104
Totals	104.944	67,164	61,304	4,413	1,447	46,954	14,350

Warren County.

TOWNSHIPS.	Total.		Land.	Water.	Cleared Land.	Forest.
	Sq. M.	Acres.	Acres.	Acres.	Acres.	Acres.
Allamuchy	20.572	13,166	13,166	....	8,699	4,467
Belvidere	1.349	863	832	31	819	13
Blairstown	31.817	20,363	20,363	....	14,688	5,675
Franklin	23.927	15,313	15,313	....	12,441	2,872
Frelinghuysen	23.759	15,206	15,206	....	12,003	3,203
Greenwich	11.067	7,083	7,083	....	6,463	620
Hackettstown	2.964	1,897	1,897	....	1,851	46
Hardwick	17.662	11,304	11,304	....	7,298	4,006
Harmony	24.323	15,567	15,345	222	11,751	3,594
Hope	30.850	19,744	19,627	117	14,896	4,731
Independence	20.164	12,905	12,905	....	9,150	3,755
Knowlton	25.651	16,417	16,171	246	13,087	3,084
Lopatcong	9.387	6,008	5,925	83	5,554	371
Mansfield	30.335	19,414	19,414	....	13,600	5,814
Oxford	34.057	21,796	21,556	240	16,526	5,030
Pahaquarry	21.155	13,539	13,118	421	3,197	9,921
Phillipsburg	1.186	759	689	70	689	....
Pohatcong	14.807	9,476	9,299	177	8,150	1,149
Washington (Borough)	1.823	1,167	1,167	....	1,141	26
Washington Township	17.796	11,389	11,389	....	9,561	1,828
Totals	364.651	233,376	231,769	1,607	171,564	60,205

Areas of Geological and Topographical Divisions.

	Square Miles.
Archæan and Paleozoic—Kittatinny Valley and Highlands	1,430
Triassic or Red Sandstone Plain	1,550
Cretaceous	1,500
Tertiary and Quaternary	3,034

POPULATION.

While it is possible that New Jersey was settled temporarily at an earlier date, there is little doubt that effectual settlement was begun at Bergen, in 1618, by the Dutch. It has been estimated that the aboriginal population, fifty years later, did not exceed 2,000. It may have been somewhat greater at the time of the settlement at Bergen, but it is doubtful if it then exceeded 3,000. The Dutch spread over Bergen, Passaic and Hudson counties, and their descendants still constitute a large portion of the population of these counties, which are all formed from the soil of the original Bergen county. From here and elsewhere about New Amsterdam, they soon found their way into the beautiful and fertile Raritan valley, populating Somerset county; and as the advantages of this new country became known, New Brunswick became settled by immigrants from the distant Dutch colony at Albany. Monmouth county, too, received a scattering Dutch population soon after. Away back in the Minisink valley the nucleus of another Dutch settlement was formed, at about the beginning of the eighteenth century, by immigrants from the banks of the Hudson, at Esopus, now Kingston. These were the principal centers of Dutch settlement in East Jersey, and they have remained nuclei about which the Holland blood still lingers, as is very evident in the family names of the present inhabitants. At Elizabethtown, the English made their first settlement in New Jersey, in 1664, after the English conquest of New Amsterdam. These settlers came from New England. Newark was settled in the same way, in 1666. Thence the English spread to the limits of, and soon began to blend with, the Dutch settlements at Bergen and on the Raritan. They populated the old county of Essex, which included what is now Union, and Middlesex north of the Raritan. Monmouth also received early an influx of English settlers, and as the Province remained under English rule, and was the property of English proprietors, the English filled up the part of East Jersey which the Dutch had not already occupied in 1664. The fusion of these two peoples began

almost immediately, and had proceeded far enough to bring them into complete accord when the war for independence began, a century later.

There were Danes and Norwegians among the settlers at Bergen, and Scotch and Irish among the English settlers, but the English and Dutch far outnumbered all other nationalities.

In West Jersey, the Dutch were the first to attempt settlement, but their settlements at Fort Nassau, in 1623 and again in 1630, met with disaster and so disheartened them that they abandoned the country.

In 1637, the Swedes settled at Tinicum, and soon after the Dutch again occupied Fort Nassau. The English came from New Haven, Connecticut, and settled on the Delaware in 1640; and although resisted by both Swedes and Dutch they eventually occupied all of West Jersey, leaving only a trace of the Swedish and Dutch blood along the Delaware, about Salem. Fairfield, Cumberland county, was named after Fairfield, Connecticut, from which place the settlers came. Greenwich, Cumberland county, was settled from New England also, with some Irish settlers added to the English. English whalers from Long Island settled Cape May, probably as early as 1640.

In 1677, 230 English Quakers settled in West Jersey. They found some scattering Swedish habitations about Raccoon creek. Yorkshire Quakers chose the land below Trenton, about Burlington, and those from London, the country about Gloucester. They all settled at the town of Burlington, however. They were soon followed by others who settled at Salem. We are told that about 1680 West Jersey became quite populous by the accession of many settlers. They were mostly Friends, and in West Jersey, from this time, English blood preponderated largely.

It is estimated that in 1682 the population of the State was 6,000 and at the beginning of the eighteenth century it was 20,000, of which 12,000 belonged to East Jersey and 8,000 to West Jersey. The militia amounted to 1,400 men. In 1737, the population amounted to 47,369, of which 26,469 belonged to East Jersey and 20,900 to West Jersey. This proportion seems to verify the previous estimate. Holmes' Annals gives an estimate of 15,000 for the year 1701.

The following tabular statement shows the population by counties at various periods during the last one hundred and fifty years. The counties are grouped, so that those which have been formed last may be near those from which they were taken off:

Population of New Jersey at Different Periods.

COUNTIES.	1737.	1745.	1785.	1790.	1800.	1810.	1820.	1830.	1840.	1850.	1860.	1865.	1870.	1875.	1880.	1885.	1890.	1895.
Bergen	4,095	3,006	....	12,601	15,956	16,603	18,178	22,412	13,223	14,725	21,618	24,636	30,122	35,516	36,786	39,880	47,226	65,251
Passaic	....	....	....	....	....	....	....	....	16,734	22,569	29,013	34,856	46,416	53,775	68,860	83,874	105,046	133,227
Hudson	....	....	....	....	....	....	....	....	9,483	21,822	62,717	87,819	129,067	163,000	187,944	240,842	275,126	328,080
Essex	7,019	6,988	....	17,785	22,269	25,984	30,793	41,911	44,621	73,950	98,877	124,441	143,839	166,812	189,929	213,764	256,098	312,000
Union	....	....	....	....	....	....	....	....	....	....	27,780	35,410	41,859	51,758	55,571	61,839	72,467	85,404
Morris	....	4,436	....	16,216	17,750	21,828	21,368	23,665	25,844	30,158	34,677	36,513	43,137	49,019	50,861	50,675	54,101	59,536
Sussex	....	....	....	19,500	22,534	25,549	32,752	20,346	21,770	22,989	23,846	23,929	23,168	24,010	23,539	22,401	22,259	22,586
Warren	....	....	....	....	....	....	....	18,627	20,366	22,358	28,433	31,523	34,336	37,389	36,589	37,787	36,553	37,283
Hunterdon	5,570	9,151	....	20,153	21,261	24,556	28,604	31,060	24,787	28,990	33,654	40,758	36,963	37,478	38,570	37,420	35,355	35,334
Mercer	....	....	....	....	....	....	....	....	21,502	27,992	37,419	41,478	46,386	49,884	58,061	66,785	79,978	85,538
Somerset	4,505	3,239	....	12,296	12,815	14,725	16,506	17,689	17,455	19,692	22,057	21,610	23,510	27,453	27,162	27,425	28,311	30,447
Middlesex	4,764	7,612	....	15,956	17,890	20,381	21,470	23,157	21,893	28,635	34,812	35,916	45,029	48,318	52,286	56,180	61,754	70,058
Monmouth	6,086	8,627	....	16,918	19,872	22,150	25,038	29,233	32,909	30,313	39,346	42,868	46,195	48,500	55,538	62,324	69,128	75,548
Ocean	....	....	....	....	....	....	....	....	....	10,032	11,176	14,262	13,628	13,707	14,455	15,586	15,974	18,789
Burlington	5,238	6,803	....	18,095	21,524	24,972	28,882	31,107	32,831	43,203	49,730	50,719	53,639	53,155	55,402	57,558	58,528	59,117
Camden	....	....	....	....	....	....	....	....	....	25,422	34,457	38,464	46,193	52,994	62,942	76,685	87,687	100,104
Gloucester	3,267	3,506	....	13,363	16,115	19,744	23,089	28,431	25,438	14,655	18,444	20,134	21,562	24,486	25,886	27,603	28,649	31,191
Atlantic	....	....	....	....	....	....	....	....	8,726	8,961	11,786	11,344	14,093	15,183	18,704	22,356	28,836	34,750
Salem	5,888	6,847	....	10,437	11,371	12,761	14,022	14,155	16,024	19,467	22,458	23,162	23,940	22,701	24,579	25,878	25,151	26,084
Cumberland	....	....	....	8,248	9,529	12,670	12,668	14,093	14,374	17,189	22,605	26,238	34,665	35,311	37,687	41,982	45,438	49,815
Cape May	1,004	1,188	....	2,571	3,066	3,632	4,265	4,936	5,324	6,433	7,130	7,625	8,349	8,190	9,765	10,744	11,268	12,855
Total.	47,369	61,403	140,435	184,198	211,949	245,555	277,426	320,823	373,306	489,555	672,035	773,700	906,096	1,019,414	1,131,116	1,278,033	1,444,933	1,672,942

Nativity of the Population.

This table shows an increase from 1785 to 1790 of 43,704, which seems very large. This cannot be accounted for by immigration following the peace with Great Britain, for it appears that the whole immigration to the United States from 1790 to 1800 did not exceed 5,000 annually. New Jersey's share of this could not have been large. There was a steady increase in immigration up to 1850, when it reached 310,004 for the United States. We may estimate that New Jersey at that time was receiving from this source 8,000 people yearly. The proportion of foreign-born residents of the United States living in New Jersey in 1850 was 2.64 per cent. It 1870 it was 3.39 per cent.; in 1880 3.65 per cent., and in 1890 3.56 per cent. It will be seen that the State has continued to receive her full share of the immigration, for her total population is but 2.25 per cent., and her area only one-quarter of one per cent. of that of the United States.

The following table shows the number of natives of the United States and of foreign-born residents in New Jersey at each census year since 1850:

Year.	Native.	Foreign-born.	Foreign-born to each 100 Inhabitants.
1850	430,441	58,364	11.93
1860	549,245	122,790	18.27
1870	717,153	188,943	20.85
1880	909,416	221,700	19.60
1885	1,027,687	250,346	19.59
1890	1,115,958	328,975	22.77
1895	1,315,913	357,029	21.34

This shows that since 1870 the increase of native-born residents has nearly kept pace with the increase of foreign-born; but it is to be noted that much of the native population since then has sprung from foreign parentage. It may be estimated that 40 per cent. of the total population have both parents foreign-born. More than one-quarter of the population of Essex, and over one-third of that of Hudson, is foreign. In Passaic, also, it is nearly one-third; in Union it is less than one-quarter, and in Middlesex less than one-fifth. These five counties have more than two-thirds of the total foreign-born population of the State.

Colored Population.

The following table shows the growth of the colored population of the State since 1790:

Date.	Colored Population.	Percentage of Total Population.	Percentage of Native Population.
1790	2,762	1.5	....
1800	4,402	2.1	....
1820	12,460	4 5	....
1850	23,810	4.9	5.5
1870	30,658	3.4	4.3
1885	41,841	3.3	4.1
1890	47,638	3.3	4.3
1895	59,010	3.5	4.5

The number of colored residents born in other States was, in 1880, 11,184, and at that time the living immigrants exceeded the living emigrants by 6,649. This influx comes mainly from Delaware, Maryland and Virginia. The increase of colored population has about kept pace with the increase of the native whites. Proximity to the coast, and a milder climate, have given this State a somewhat larger proportion of colored population than States west, on the same parallel of latitude.

Urban and Rural Population.

Almost the whole increase of population of the State for the last quarter century has been in the cities, as the following table will show:

Date.	Population of Cities Over 8,000.	Population of Cities Over 2,000.	Village and Rural Populations.
1850	69,730	134,300	355,255
1870	329,638	436,661	469,435
1880	503,999	681,687	449,429
1885	672,537	806,852	471,171
1890	820,681	981,475	463,458
1895	992,834	1,158,766	514,176

This shows the rural population to have remained nearly stationary, while the population in the cities is about three times what it was in 1870. In order to show accurately the increase in urban population, we must have all places of over 2,000 inhabitants, as the increase in population of cities of over 8,000 inhabitants may be due partly to the absorption of smaller towns. Furthermore, the population of all places exceeding 2,000 inhabitants in this State is essentially urban or suburban, and does not in any sense belong to the rural population.

In certain purely agricultural counties, such as Sussex, Warren, Hunterdon, Somerset and Salem, there has been quite a marked decrease in the rural population, amounting in the aggregate to some 10,000, but this has been more than offset by an increase in the agricultural population of Monmouth, Mercer, Burlington, Gloucester and Cumberland, amounting to some 32,000.

The most rapid increase in city population has taken place in what we have heretofore termed the Metropolitan district. This district may be taken to include the counties of Hudson, Essex and Union, with Passaic northward to Paterson, and Bergen to Hackensack and Englewood, in our own State; New York, Kings and Richmond, with Long Island City and Newtown in Queens county, in the State of New York. Its magnitude and growth are shown in the following table compiled from the United States census:

YEAR.	METROPOLITAN DISTRICT.		NEW JERSEY PORTION OF SAME.		NEW YORK CITY.	
	Population.	Per cent. increase.	Population.	Per cent. increase.	Population.	Per cent. increase.
1840......	453,374	....	72,404	....	316,392	....
1850......	798,066	76.0	116,932	61.8	519,983	64.4
1860......	1,375,400	72.3	224,617	92.0	830,369	60.0
1870......	1,815,454	32.0	370,957	65.0	971,273	17.0
1880......	2,387,910	31.5	516,192	39.1	1,206,299	24.2
1890......	3,180,038	33.2	726,442	40.8	1,515,301	25.6

For the last three decades the whole district has increased in population quite uniformly at the rate of 32.2 per cent. per decade. The New Jersey portion has preserved an increase of 40 per cent. for the last two decades. We may estimate the future increase at 30 and 40 per cent. respectively. This gives the following future population:

Date.	Metropolitan District.	New Jersey Portion of the Same.
1900..	4,134,000	1,017,000
1910..	5,374,000	1,424,000
1920..	6,986,500	1,993,000
1930..	9,082,000	2,791,000
1940..	11,807,000	3,907,000
1950..	15,349,000	5,470,000

This forecast of figures is based entirely on the United States census, and, from present indications, is more likely to prove too small than too large. The State census of 1895 shows that this population had at that time already reached 900,000, but the prediction may stand as a conservative estimate, and the rate of increase may be somewhat faster during the earlier portion, and somewhat slower during the latter part of the period.

It is impossible to determine just how much of this population should be considered suburban to New York. Newark and Paterson both lie within this area, and are each important manufacturing centers. Their growth is to a degree independent of their proximity to New York. The cities of Hudson county are more plainly a portion of or dependent upon New York. It will be noted that the New Jersey portion of the metropolitan district grows more rapidly than the New York portion. The facilities for communication between New Jersey and New York City are improving quite as rapidly as elsewhere in the district, and under such conditions northeastern New Jersey must continue to grow very rapidly.

Within the metropolitan district in New Jersey there are three quite well-defined centers of population. That part of Hudson county lying between the Hackensack river and the Hudson, although it is divided into seven distinct communities, is practically one city, and comprises a total population of 303,293 within an area of 23.1 square miles. Newark and the neighboring towns of Harrison, Kearny, Belleville, Bloomfield, Montclair, Orange and East Orange lie contiguous, and are closely connected. They include a population of 301,100 within an area of 46.5 square miles. The third part is not so compactly built up. It comprises Paterson, Passaic, Rutherford and the townships of Acquackanonck, Bergen and Union, containing a population of 132,976 in an area of 36.8 square miles. This district lies immediately adjacent to the Newark district, and while at present there is some open country lying between their more densely-populated sections, they seem to be destined to ultimately grow together. Near Philadelphia, Camden, Gloucester and small towns within twelve miles of Camden comprise a population of about 90,000, which may be considered suburban to the city of Philadelphia. Outside of these centers the only places exceeding 20,000 inhabitants are Trenton, 62,518, and Elizabeth, with 43,834. The accompanying table, showing the population of the towns and cities at various dates, exhibits more fully the remarkable growth of the cities of the State:

Population of Towns and Cities of Over 2,000 Inhabitants.

	1895.	1890.	1885.	1880.	1870.	1850.	REMARKS.
Asbury Park	3,761	2,900 e	2,124	2,260	....	....	Including Ocean Grove in 1880.
Atlantic City	18,329	13,055	7,942	5,477	1,043	....	
Bayonne	19,856	19,033	13,080	9,372	3,834	....	
Belleville Township	4,568	3,487	3,285	3,004	3,644	1,800	
Bloomfield Township	8,093	7,708	6,502	5,748	4,580	2,000	
Boonton	3,276	2,981	2,390	2,277	2,000	....	
Bound Brook	2,030	....	....	....	....	....	
Bordentown	5,176	5,090	4,653	4,258	4,000	2,725	
Bridgeton	13,292	11,424	10,065	8,722	6,830	2,446	
Burlington	7,844	7,264	6,653	6,090	5,817	4,536	
Camden	63,467	58,313	52,884	41,659	20,045	9,479	
Cape May City	2,452	2,136	....	....	....	....	
Chambersburg Twp.	....	....	8,542	5,437	....	....	Now a part of Trenton.
Dover	5,021	4,000 e	3,170	2,958	1,900	....	
East Orange Township	17,927	13,282	10,328	8,349	4,315	....	
Elizabeth	43,834	37,764	32,119	28,229	20,832	4,000	
Englewood Township	5,433	4,785	4,429	4,076	....	....	
Flemington	2,060	....	....	....	....	....	
Freehold	3,157	2,932	2,124	2,432	....	....	
Gloucester	6,225	6,564	5,966	5,347	3,682	2,188	
Guttenberg	3,626	1,947	....	....	....	....	
Hackensack	7,282	6,004	4,983	4,248	4,929	3,506	Includes New Barbadoes Township. In 1871 part to Midland.
Hackettstown	2,594	2,417	2,645	2,502	2,202	1,200	
Haddonfield	2,580	2,502	....	....	....	....	
Harrison	9,674	8,338	6,806	6,898	4,129	....	
Hoboken	54,083	43,648	37,721	30,999	20,297	....	
Irvington	3,388	2,100 e	....	....	....	....	
Jersey City	182,713	163,033	153,513	120,722	82,546	6,856	
Kearny	10,487	7,064	3,338	....	....	....	
Keyport	3,386	3.411	3,063	2,753	2,866	....	
Lambertville	4,620	4,142	4,067	4,183	3,842	1,417	
Long Branch	7,333	7,231	5,140	3,833	....	....	
Madison	3,250	2,469	....	....	....	....	
Millham	....	....	2,388	1,585	677	....	Now a part of Trenton.
Millville	10,466	10,002	8,824	7,660	6,101	2,332	
Montclair Township	11,758	8,656	6,327	5,147	2,858	....	

Population of Towns and Cities of Over 2,000 Inhabitants—Continued.

	1895.	1890.	1885.	1880.	1870.	1850.	REMARKS.
Morristown	10,290	10,155	6,300 e	5,418	5,000	3,300	
Mount Holly	5,750	5,376	5,006	4,630	4,018	2,000	Includes Northampton Township.
Newark	215,806	181,830	152,988	136,508	105,059	38,894	
New Brunswick	19,910	18,603	18,258	17,166	15,058	10,019	
Newton	3,426	3,003	2.648	2,513	2,403	....	
North Bergen	3,427	5,715	5,459	4,268	3,082	....	
North Plainfield	4,245	3,620 e	3,100 e	2,580 e	....	....	
Ocean Grove	3,580 e	2,754	....	....	....	....	
Orange	22,792	18,844	15,231	13,207	9,348	4,385	
Oxford	2,040	2,883	2,520 e	2,656	....	....	
Passaic	17,894	13,028	8,826	6,532	3,400	....	
Paterson	97,344	78,347	63,273	51,031	33,579	11,334	
Perth Amboy Township	13,030	9,512	6,311	4,808	2,861	....	
Plainfield	13,629	11,267	8,913	8,125	5,095	2,447	
Phillipsburg	9,031	8,644	8,058	7,181	5,932	....	
Princeton	4,411	4,231	3,438	3,209	2,798	....	
Rahway	7,945	7,105	6,861	6,455	6,258	3,306	
Raritan	2,693	2,556	2,244	2,046	....	....	
Red Bank	4,888	4,145	3,186	2,684	2,086	....	
Rutherford	6,222	3,731	2,579	2,299	....	....	Includes East Rutherford.
Salem	6,337	5,516	5,516	5,056	4,555	3,052	
Somerville	4,514	3,861	3,316	3,105	2,236	....	
South Amboy	5,571	4,330	4,054	3,648	....	....	
South Orange	5,108	4,970	4,225	2,178	....	....	
Trenton	62,518	57,458	34,386	29,910	22,874	6,461	
Union	13,336	10,643	8,398	5,849	4,640	....	1870. Includes Union Township.
Union Township	5,005	2,127	....	....	....	....	
Van Vorst	....	....	....	....	....	4,617	Now a part of Jersey City.
Vineland	4,126	3,822	3,170	2,519	2,000	....	
Washington	3,588	2,834	2,597	2,142	....	....	
Weehawken	2,577	1,943	....	....	....	....	
West Hoboken	18,296	11,665	7,162	5,441	....	....	
Woodbury City	3,858	3,911	3,278	2,298	1,965	....	

"e" indicates estimated population.

Distribution by Natural Divisions.

Arranged by geological and topographical divisions, the following was the distribution of the population for the given census years:

	Total Population.	In Cities of Over 2,000 Population.	Rural Population.	Rural Population per Square Mile.
1870.				
Archæan and Paleozoic......	97,948	14,437	83,511	58
Triassic...........................	491,148	333,269	157,879	102
Cretaceous.........................	203,960	72,981	130,979	87
Tertiary and Quaternary...	113,040	15,974	97,066	32
The State..................	906,096	436,661	469,435	62
1885.				
Archæan and Paleozoic......	107,431	24,028	83,403	58
Triassic...........................	747,789	600,847	146,942	95
Cretaceous	271,153	149,852	121,301	81
Tertiary and Quaternary...	151,660	32,125	119,535	40
The State..................	1,278,033	806,852	471,181	62
1895.				
Archæan and Paleozoic......	105,030	28,976	76,054	53
Triassic	1,047,491	876,522	170,969	110
Cretaceous	344,225	197,262	146,963	98
Tertiary and Quaternary...	176,196	56,006	120,190	40
The State..................	1,672,942	1,158,766	514,176	68

This shows the changes which have taken place in the population of the several districts during the last quarter century. The most rapid increase in total population has been on the Triassic or Red Sandstone plain, which includes most of the cities of the State. The column of rural population, however, shows conditions more intimately related to the geology. We find from this that the Archæan and Paleozoic regions, including the hilly portions of northern New Jersey, show a stationary rural population from 1870 to 1885, and a decrease of about 10 per cent. from 1885 to 1895. This is agricultural and mining population mainly. The Triassic shows a decrease of about 8 per cent. in rural population from 1870 to 1885, and an increase of about 17 per cent. during the last ten years. This increase will be found, on close analysis, to be entirely due to growth of scattering suburban population. The Cretaceous district shows a decrease in rural population of about 7 per cent. during the period

from 1870 to 1885, or about 9,600 in all. This, however, is found to be due entirely to absorption of this amount of the population into the cities, either by small towns reaching above the 2,000 limit in the interval, or by extension of city limits. The rural population was practically stationary during this period. From 1885 to 1895 there is an increase of over 20 per cent., or about 25,000 in all. This appears to be mainly an increase in the agricultural population. The slight increase shown in the rural population of the Tertiary district, amounting to about 23,000, is partly due to seaside development, and also, to a considerable extent, to the agricultural development of pine lands in Cumberland, Atlantic, Salem, Gloucester and Camden counties.

The total population of the State amounts to 223 for each square mile of land surface.

MAGNETIC SURVEY OF NEW JERSEY.

Anyone who has studied the isogonic chart for 1885, prepared by Mr. Chas. A. Schott, and published in the U. S. Coast and Geodetic Survey report for 1882, must have noticed that the more numerous the stations are, the more irregular are the isogonic curves. It had been observed during the progress of the topographic survey of the State that the distribution of magnetic declination was much more irregular than has been generally supposed, and that even when local attraction was eliminated, variations of one or two degrees prevailed over quite extended areas. It was believed that a large number of observations taken within a short period of time, distributed over the State and not aiming at extreme accuracy, would be more serviceable in gaining a fuller knowledge of distribution than would very refined observations at a few stations. Consequently in October, 1887, two parties were placed in the field, equipped with good surveying transits, the needles of which were six inches in length and had been put in perfect order and carefully compared with each other and with a standard needle. One instrument was furnished with a Saegmuller solar attachment and the other was supplemented by a Gurley solar compass.

Having reached a locality where observations were desired, a meridian would be determined by observation on a circumpolar star, either Polaris or 51 Cephei, and from this a traverse would be run out

over an area of two or three square miles and the declination carefully observed at each station, readings being occasionally taken with the solar compass.

The readings of the solar compass were thus checked, and so at the next locality it could be used alone and two localities could be occupied in one day, or in case the stars were obscured the work could proceed without loss of time, as the solar apparatus would be again checked at the first favorable opportunity.

In this way observations were obtained at 121 localities within a period of six weeks by two working parties. These observations have been supplemented by 37 other observations made by the Topographer in charge, and a few other observers, within a few years, all being reduced to the epoch 1888.0. These 158 stations within the State and a few in neighboring States, taken from Mr. Schott's collections, have been utilized in preparing the isogonic chart accompanying this article. In drawing the curves no attempt has been made to satisfy all of the observations, but only such as pointed indisputably to a disturbance covering a considerable extent of country, and not purely local. It should be noted that the declinations given in the list following and utilized in the chart, are the mean of the declinations observed at several stations about the given locality, and that in making up these means, extreme results which showed evidence of purely local attraction were thrown out.

No attempt will here be made to explain the disturbances shown by the isogonic chart; some of the peculiarities of distribution observed may be pointed out, but theories as to their causes would be premature. A much larger number of observations would be necessary to this end.

In southern New Jersey it may be noted that in the vicinity of Philadelphia and Mount Holly the increase of declination going northward is at about the rate of one degree in 4 miles, but elsewhere it is only at the rate of one degree in from 8 to 12 miles.

There seems to be a general deflection of the needle westward, amounting to about half a degree, about Trenton, N. J., Philadelphia, Norristown and West Chester, Pa., from which it recovers again at Lambertville and Doylestown.

There is an outcrop of Archæan rock on this area of west deflection, and it is as we approach this outcrop from the sand and clay regions

that the more rapid increase of west declination above noted occurs. Generally, over southern New Jersey the distribution is very uniform.

On the Red Sandstone plain the only disturbances are in the vicinity of the trap ridges, and here too we find a more rapid increase of west declination as we approach the Archæan Highlands. The disturbances about some of the trap ridges are marked. The declination at Tappan, near the New York line, is 7° 57′, while on top of Palisades mountain, two miles east, it is 9° 02′, and passing over the crest we find along the bank of the Hudson 8° 10′. At Hackensack it is 7° 49′, and a very uniform increase occurs in going east to the crest of the Palisades at Linwood, where it is 9° 03′. Passing down to the bank of the Hudson it falls back again to 7° 57′. At Weehawken also the declination at the top of the ridge is 1½° greater than in the valley west, and about ½° greater than at the eastern foot of the Palisades. This tendency of the needle toward a perpendicular to the crest line of the trap ridges is noticeable at other points also. At High mountain, north of Paterson, it amounts to 45′, at the ridge east of Pompton to 1½°, at Plainfield to 40′, at Martinsville to 30′, and at Goat Hill, near Lambertville, to 15′ or less. A series of stations across the Watchung mountains between Orange and Livingston gave no evidence whatever of such a tendency, and the same is true of a line across Rocky Hill between Princeton and Blawenburgh. Purely local attraction was observed, however, at all of these points on the trap. The effect of Palisades mountain was so continuous and well verified, that it was thought best to exhibit it in the isogonic chart; but at other points it was not shown, being treated as ordinary local attraction.

The greatest disturbance of the isogonic curves occurs in and about the Archæan Highlands. Local attraction due to magnetic ore deposits is very common here, making observations of the general distribution difficult. In general it may be said that the needle swings toward the axis of the Archæan mountain masses, which increases declination on the southeast slopes and decreases it on the northwest. The increase in declination in passing from the Red Standstone up on the Highlands is about one degree. This tendency of the needle toward the mountain is not so noticeable in the case of Musconetcong and Schooley's mountains. About Bartley, in German valley, the needle seems to be deflected about two degrees westward, and a line across from the ridge at Chester shows a rapid increase in declination until the foot of Schooley's mountain is

reached, but on reaching the top of the mountain there is a decrease at once of more than two degrees. The declination in the valley at Greenwood lake and Newfoundland is from 1° to $1\frac{3}{4}$° less than it is on the mountains either side.

Throughout the eastern side of Kittatinny valley the needle is deflected eastward from the normal position. This deflection amounts to $\frac{3}{4}$° at Phillipsburgh, $1\frac{1}{2}$° at Belvidere and $1\frac{3}{4}$° at Vernon. Pochuck mountain causes a marked disturbance, amounting to about 2° at a maximum. Once out of the influence of the Highlands no disturbances are noted on the west side of Kittatinny valley and on the mountain.

Enough has been observed to show that a close relationship exists between geological structure and magnetic distribution, that the principal irregularities in distribution occur in the vicinity of outcrops of Archæan or gneissic rocks, that the traps may cause equally great disturbances, although as their extent is less in New Jersey than that of the Archæan rocks, these disturbances are less noticeable, and that disturbances due to either kind of rock are not confined to the actual outcrop, but seem to be felt while the rocks are still below the surface. This last suggests at once the query—may not detailed magnetic surveys sometimes be made useful in the study of stratigraphical geology, when the relationship between geological structure and the magnetic forces comes to be better understood? At all events the knowledge of the existence of these irregularities in magnetic distribution, carries with it a useful lesson to the land surveyor.

Collection of Magnetic Declinations.

At the beginning of the study of this subject, inquiries as to observed declinations and change of bearing in old lines were sent out to most of the surveyors of the State. The results were meager, although all applied to showed interest and a disposition to aid in making such a collection. The Survey is indebted to many of these gentlemen whose names are mentioned in the remarks after the information which they contributed. Mr. A. H. Konkle, of Newton, deserves special mention, as he was at considerable pains to procure the results sent, going into the field for that purpose. Where authority is not given the results were obtained from the magnetic survey, made in 1887, by the Topographer.

The Coast Survey collections have been largely drawn upon and every available source besides. Naturally the publication of this collection will bring to light much more material, as did the early collections by Mr. Schott, but it is doubtful if much more is needed than is here given for the use of surveyors, for the great uncertainties introduced by the irregularities of distribution which have been shown, make surveying with the compass in northern New Jersey little better than guesswork, while where these irregularities do not occur, the decennial series of computed declinations for New York and Philadelphia will be found to apply very closely. While the effort is made to make this paper as useful as possible to the surveyors of the State, it must be remembered that its primary object is to record the irregularities of magnetic distribution brought out by a more than usually detailed survey, and to pave the way for an explanation of their causes.

Atlantic County.

ATLANTIC CITY.

Date.	Declination West.	
1860.6.	4° 54′.	United States Coast Survey Report, 1881.
1885.	(6° 48′.)	Schott's computation, Report, 1881.
1887.8.	6° 22′.	About the light-house. Several stations.

HAMMONTON.

1885.9.	5° 53′.	One mile northwest. Topographic Survey. (See Winslow, Camden county,)

MAYS LANDING.

1875.	5° 22′.	Mean of 13 trials by West Jersey Association, court-house meridian (corrected for local attraction).
1887.8.	(5° 38′.)	South end of court-house meridian (local attraction).
1887.8.	5° 55′.	North end of court-house meridian.
1887.8.	5° 52′.	Average about the village.

Bergen County.

DARLINGTON.

1879.6.	9° 40′.	On brow of mountain, just west. Topographic Survey.

ENGLEWOOD.

1839.	5° 36′.	J. H. Serviss, re-survey of old road at Fort Lee.
1877.6.	7° 53′.	J. H. Serviss, observer.
1885.4.	8° 27′.	J. H. Serviss, observer.
1887.8.	8° 29′.	Near Nordhoff station.

Date.	Declination West.	
		FAIRLAWN.
1887.8.	8° 06′.	Vicinity of railroad station.
		HACKENSACK.
1887.8.	7° 49′.	From Maywood to the West Shore railroad.
		LINWOOD.
1887.8.	9° 03′.	Average for top of Palisade mountain, only slight variation.
1887.8.	7° 57′.	At eastern base of Palisade mountain. There is a steady increase of declination from Hackensack to Linwood, at top of the Palisades, then a fall of over a degree down the eastern foot.
		MAHWAH.
1887.8.	8° 40′.	West of the Ramapo river, at base and on top of mountain.
1887.8.	8° 23′.	Vicinity of village.
		PALISADES, N. Y.
1874.6.	9° 15′.	Prof. E. A. Bowser, Boundary Survey.
1887.8.	9° 02′.	Average on top of trap ridge. Not much local attraction on top, but 2½° observed at one point on the slope.
		RAMAPO, N. Y.
1883.6.	9° 20′.	Top of High Torn. A. A. Titsworth.
		SLOATSBURGH, N. Y.
1874.6.	7° 42′.	Prof. E. A. Bowser, Boundary Survey.
		TAPPAN, N. Y.
1887.8.	7° 57′.	On sandstone west of foot of Palisades.
		TEANECK.
1887.8.	8° 09′.	Average on top of ridge.

Burlington County.

		BASS RIVER.
1885.6.	6° 30′.	H. S. Haines.
		BORDENTOWN.
1846.4.	4° 26′.	At White Hill, United States Coast Survey Report, 1882.
1885.0.	7° 9′.	At White Hill, Schott's computation, United States Coast Survey Report, 1882.
1885.8.	7° 03′.	In the town. Topographic Survey.

Date.	Declination West.	
		BRISTOL, PA.
1846.5.	4° 28′.	United States Coast Survey Report, 1882.
1885.	7° 11′.	Schott's computation, United States Coast Survey Report, 1882.
		BROWN'S MILLS.
1885.8.	6° 53′.	Topographic Survey.
		COLUMBUS.
1885.8.	7° 15′.	At Bishop's barn, 2 miles east. Topographic Survey.
		ELLISDALE.
1885 8.	6° 45′.	At Stony Hill, near county line.
		LITTLE EGG HARBOR LIGHT.
1846.9.	4° 28′.	On Tucker's island, United States Coast Survey Report, 1882.
1885.	7° 09′.	Schott's computation, United States Coast Survey Report, 1882.
		MOUNT HOLLY.
		Observations by West Jersey Surveyors' Association, at meridian, in the court-house yard.
1866.7.	5° 36′.	Mean of 10 observations with different instruments.
1870.6.	6° 00′.	Mean of 15 observations with different instruments.
1873.6.	6° 10′.	Mean of 10 observations with different instruments.
1875.0.	6° 12′.	Mean of 16 observations with different instruments.
1877.6.	6° 32′.	Mean of 9 observations with different instruments.
1879.6.	6° 42′.	Mean of 9 observations with different instruments.
1881.6.	6° 50′.	Mean of 12 observations with different instruments.
1882.6.	6° 53′.	Mean of 11 observations with different instruments.
1885.6.	6° 57′.	Mean of 16 observations with different instruments.
		N. B.—It seems that local attraction exists at the south end of the county meridian to the amount of not less than +23′. Hence, while the above are of interest as showing westward movement, they do not give absolute values correctly.
1887.9.	6° 51′.	Observed on same point with instrument used in magnetic survey.
1887.9.	6° 28′.	Mean about village on top of mount and northward.
		SHAMONG STATION.
1885.9.	6° 13′.	On Apple-pie hill. Topographic Survey.
1887.9.	6° 36′.	Vicinity of village.
		SMITHVILLE.
1885.8.	6° 32′.	Topographic Survey.
		TUCKERTON.
1885.6.	6° 57′.	H. S. Haines.
1887.9.	6° 52′.	Vicinity of village.

Camden County.

Date.	Declination West.	
		BERLIN.
1884.6.	5° 46′.	At Coast Survey station, 2 miles northeast of village. A. A. Titsworth.
1885.9.	5° 35′.	At Coast Survey station. Topographic Survey.
		CAMDEN.
1887.8.	6° 10′.	Vicinity of Liberty Park.
		HADDONFIELD.
1885.9.	6° 24′.	Topographic Survey.
1887.8.	6° 10′.	Southwest side of village.
		WATERFORD.
1885.9.	5° 49′.	At village. Topographic Survey.
		WINSLOW.
1887.8.	5° 57′.	Vicinity of Winslow Junction.
		PHILADELPHIA, PA., FROM SCHOTT'S TABLES.
1701.	8° 30′.	Scull, Sill. Journal, Vol. 23, 1833.
1710.	8° 30′.	Th. Whitney, Sill. Journal, Vol. 34, 1838.
1750.	5° 45′.	Kalm's Travels, reference as above.
1793.	1° 30′.	Th. Whitney, reference as above. Also Brooks, Sill. Journal, Vol. 23, 1833.
1802.	1° 30′.	Howell, reference as above.
1804.	2° 00′.	By several men of science, reference as above.
1804.	2° 10′.	Th. Whitney, Sill. Journal, Vol. 34, 1838.
1813.	2° 25′.	D. McClure, reference as above.
1813.	2° 27′.	Whitney, Sill. Journal, Vol. 23, 1833.
1837.	3° 52′.	W. R. Johnson, Sill. Journal, Vol. 34, 1838.
1840.5.	3° 37′.	Dr. A. D. Bache, Girard College. Magnetic Survey of Pennsylvania.
1841.7.	3° 54′.	Reference as above.
1846.4.	3° 51′.	Dr. J. Locke, Girard College.
1855.7.	4° 32′.	C. A. Schott, Girard College, United States Coast Survey.
1862.6.	5° 00′.	C. A. Schott, Girard College, United States Coast Survey.
1872.8.	5° 28′.	A. H. Schott, Girard College, United States Coast Survey.
1877.8.	6° 02′.	J. B. Baylor, Girard College, United States Coast Survey.
1884.7.	6° 22′.	Edwin Smith, Girard College, United States Coast Survey.

Cape May County.

CAPE MAY CITY.

Date.	Declination West.	
1846.5.	3° 05′.	United States Coast Survey Report, 1881, at light-house.
1849.7.	3° 05′.	N. C. Price.
1850.7.	3° 11′.	N. C. Price.
1855.6	3° 45′.	United States Coast Survey Report, 1881, at light-house.
1857.7.	3° 30′.	N. C. Price.
1874.5.	4° 38′.	United States Coast Survey Report, 1881, at light-house.
1881.	5° 06′.	N. C. Price.
1885 0.	5° 23′.	United States Coast Survey Report, 1882, Schott's computation.
1887.8.	5° 11′.	Average of several stations between Cape May City and light-house.

OCEAN VIEW.

1887.8.	5° 40′.	Vicinity of railroad station.

TOWN BANK.

1846.5.	2° 59′.	United States Coast Survey Report, 1881.
1885 0.	5° 30′.	United States Coast Survey Report, 1882, Schott's computation.

Cumberland County.

BRIDGETON.

1846.5.	2° 59′.	United States Coast Survey Report, 1881, "Hawkins," just west of Bowentown station.
1885.0.	5° 30′.	United States Coast Survey Report, 1882, "Hawkins" Schott's computation.
1872.6.	4° 31′.	Mean of 17 trials, West Jersey Association, county meridian.
1884.9.	5° 18′.	Mean of 9 trials, West Jersey Association, county meridian.
1887.8.	5° 15′.	On same county meridian used above.
1887.8.	5° 19′.	Mean of several stations about town.

EGG ISLAND LIGHT-HOUSE.

1846.5.	3° 03′.	United States Coast Survey Report, 1881.
1885.0.	5° 34′.	Schott's computation, United States Coast Survey Report of 1882.

GREENWICH.

1846.5.	3° 14′.	United States Coast Survey Report, 1881, at Pine mountain, 2 miles north.
1885.	5° 45′.	United States Coast Survey Report, 1882, at Pine mountain, Schott's computation.

PORT NORRIS.

1846.5.	3° 04′.	United States Coast Survey Report, 1881.
1885.0.	5° 35′.	United States Coast Survey Report, 1882, Schott's computation.
1887.8.	5° 24′.	Average of several stations.
1883 5.	5° 05′.	At Maurice river light, 3 miles south.

Essex County.

Date.	Declination West.	
		COOK'S BRIDGE.
1887.9.	8° 02′.	Both sides of river.
		N. B.—It is noticeable that there is little variation on a line from Orange to Hanover. The trap ridges appear to exert no general effect on the needle, only local.
		LIVINGSTON.
1887.9.	8° 10′.	No effect observed from Riker hill.
		ORANGE.
1887.9.	8° 05′.	Vicinity of Orange and Llewellyn Park up to brow of mountain.
1887.9.	8° 00′.	Crest of First mountain and valley west along Mt. Pleasant turnpike. Local attraction observed, amounting to 2½°, on top of mountain.
1887.9.	8° 05′.	Crest of Second mountain, Mt. Pleasant turnpike. Local attraction, amounting to 1½°, observed on west slope.
		NEWARK.
1846.4.	5° 35′.	United States Coast Survey Report, 1881.
1847.	5° 45′.	Reported by P. Witzel.
1878.	7° 40′.	Observed by P. Witzel.
1887.8.	7° 49′.	At Harrison.

Gloucester County.

		CLARKSBORO.
1870.1.	5° 48′ (?).	Wm. Haines.
		CLAYTON.
1885.9.	5° 46′.	Topographic Survey.
		NEWFIELD.
1887.8.	5° 45′.	South of the village.
		WOODBURY.
1846.5.	3° 45′.	United States Coast Survey Station Chew, 2 miles southwest of village.
1865.0.	4° 48′.	Wm. Haines, at court-house.
1867.6.	4° 49′.	Mean of 23 trials, West Jersey Association, at court-house.
1870.0.	4° 46′.	Wm. Haines, at court-house.
1874.6.	5° 11′.	Mean of 15 trials, West Jersey Association, at court-house.
1883.6.	6° 01′.	Mean of 4 trials, West Jersey Association, at court-house.
1887.8.	6° 02′.	Mean of several stations northwest of village.

Hudson County.

Date.	Declination West.	
		JERSEY CITY.
1841.	5° 52′.	W. C. Wetmore, U. S. N. See Winfield's Land Titles. At court-house.
1841.1.	6° 06′.	Douglas' map of city.
1871.4.	7° 55′.	Delos E. Culver. Winfield's Land Titles.
		HARRISON.
1887.8.	7° 49′.	Top and east side of ridge. At west foot of ridge a value of 7° 35′ was observed.
		SECAUCUS.
1887.8.	8° 45′.	Along Paterson plank road.
		WEST HOBOKEN.
1840.7.	5° 53′.	United States Coast Survey, just west of monastery.
1887.8.	9° 22′.	Average of top of ridge north of monastery. Much local attraction exists hereabouts, due partly to natural, partly to artificial causes.
1887.8.	8° 55′.	Along base of Palisades from Weehawken to Guttenberg. 9° 32′ was noted here at one station.
		NEW YORK, N. Y., FROM SCHOTT'S TABLES.
1684.	8° 45′.	Philip Welles, Surveyor-General. Report of the New York Commissioners on the Connecticut Boundary, made in April, 1857. Sen. Doc. 165, p. 155.
1691.	8° 45′.	On Staten Island. Geological Survey of New York, 1858, E. Duxbury's patent.
1714.8.	8° 45′.	John Beatty, Deputy Surveyor, on map of Livingston's Manor. O'Callaghan's Doc. History of New York, iii., 414.
1723.	7° 20′.	G. Burnett. Prof. E. Loomis' collection, Sill. Journal, Vol. 34, 1838.
1724.	7° 20′.	Cadwallader Colden. Report of Commissioners on the Connecticut Boundary, 1857.
1750.	6° 22′.	Mr. Alexander. Prof. E. Loomis' collection, Sill. Journal, Vol. 34, 1838.
1755.	5° 00′.	Mr. Evans, as above.
1789.	4° 20′.	Mr. Evans, as above.
1824.	4° 40′.	Blunt's map, as above.
1834.	4° 50′.	Capt. Owen, as above.
1837.	5° 40′.	Prof. J. Renwick, Columbia College, as above.
1840.5.	5° 01′.	At Howard, Staten Island. United States Coast Survey.
1840.6.	5° 53′.	At Bergen Neck station. United States Coast Survey. West Hoboken.
1841.	6° 06′.	Douglas' map of New Jersey.
1844.6.	6° 13′.	United States Coast Survey at Columbia College.

Date.	Declination West.	
1845.7.	6° 25′.	United States Coast Survey at Columbia College.
1846.3.	5° 10′.	United States Coast Survey at Bloomingdale Asylum.
1855.6.	6° 40′.	United States Coast Survey at Governor's Island.
1855.6.	7° 02′.	United States Coast Survey at Bedloe's Island.
1855.6.	6° 28′.	United States Coast Survey at receiving reservoir, Central Park.
1874.6.	7° 23′.	Report of Chief of Engineers, U. S. A. Chart of Way Reef, Hell Gate, 1875.
1885.8.	9° 00′.	J. B. Baylor, United States Coast Survey in Riverside Park. [Not used on account of local deflection. Sch.]

Hunterdon County.

CUSHETUNK OR PICKLES MOUNTAIN.

1883.8. 7° 29′. Topographic Survey at Geodetic station (Pickles).

FLEMINGTON.

1887.9. 7° 14′. Vicinity of town.

FRENCHTOWN.

1887.9. 7° 05′. At town above and below bluff.
1887.9. 7° 15′. From one to two miles northeast.

GLEN GARDNER.

1887.8. 6° 59′. One mile northeast of village, local attraction amounting to 10° observed hereabouts.

HIGH BRIDGE.

1887.8. 8° 18′. One mile northwest of village.

LAMBERTVILLE.

1887.9. 6° 55′. Vicinity of town.
1887.9. 7° 11′. Crossing trap ridge from one to three miles southeast of town; local attraction of 45′ observed, with a slight tendency to throw the needle away from axis of ridge.

LEBANON.

1887.8. 7° 52′. Vicinity of Potterstown and Lebanon.
1887.8. 7° 45′. On mountain 1 to 2 miles southeast of Cokesbury. No general effect is observable in approaching and mounting Fox hill.

PATTENBURG.

1887.8. 6° 53′. Vicinity of village. Musconetcong mountain attracts the needle about here and Valley station, up both slopes.

POTTERSVILLE.

1883.8. 7° 46′. On hill 1 mile southwest.

VALLEY STATION, CENTRAL RAILROAD OF NEW JERSEY.

Date.	Declination West.	
1887.8.	7° 04′.	Half a mile north of station, in valley.
1887.8.	6° 28′.	At foot of Musconetcong mountain.
1887.8.	6° 42′.	Crest of Musconetcong mountain. Varies from 5° 17′ to 7° 57′ (local attraction).

Mercer County.

HAMILTON SQUARE.

1885.8.	6° 58′.	Topographic Survey.

HIGHTSTOWN.

1887.8.	7° 18′.	South and west of village.

PRINCETON.

1810 5.	7° 00′.	Silliman's Journal, 1838. (This seems erroneous.)
1852 6.	5° 32′.	At Mt. Rose, 3½ miles northwest of village. United States Coast Survey.
1887.9.	7° 09′.	About the village.
1887.9.	7° 21′.	Crest of trap ridge north-northwest of village. Local attraction amounting to 30′ observed.

TRENTON.

1887.8.	7° 13′.	East of city, extending to Pond run.

Middlesex County.

JAMESBURG AND VICINITY.

1761.	4° 33′.	Henry M. Thomas. Bearings of old lines.
1795.	3° 11′.	
1799.	2° 43′.	
1815.	3° 12′.	
1826.	3° 50′.	
1829.	3° 52′.	
1887.	7° 25′.	

NEW BRUNSWICK.

1800.	2° 24′.	Bearings of old lines, taken by Geo. Hill.
1804.	2° 30′.	Bearings of old lines, taken by Jas. M. Cobb.
1811.	3° 19′.	Bearings of old lines.
1814.6.	3° 07′.	Bearings of old lines, taken by Geo. Hill.
1815.9.	3° 13′.	Bearings of old lines, taken by Geo. Hill.
1830.5.	3° 34′ (?).	Bearings of old lines, taken by Geo. Hill.
1836.6.	4° 40′.	Bearings of old lines, taken by Geo. Hill.
1838.5.	4° 45′.	Bearings of old lines, taken by Geo. Hill.
1846.0.	5° 23′ (?).	Bearings of old lines, taken by Geo. Hill.

Date.	Declination West.	
1848.6	5° 10′.	Bearings of old lines, taken by Geo. Hill.
1850.8.	5° 23′.	Bearings of old lines, taken by Geo. Hill.
1863 0.	6° 09′.	Old deed; reported by Geo. Hill.
1864.	6° 10′.	Prof. Geo. H Cook, at county meridian.
1866.	6° 00′ (?).	T. N. Doughty.
1870.	6° 24′.	Bearings of old lines.
1880.	7° 15′.	Prof. E. A. Bowser.
1884.	7° 30′.	Jas. M. Cobb.
1886.	7° 30′.	Geo. Hill.
1887.	7° 32′.	Geo. Hill.
1887.8.	7° 34′.	Observed at Rutgers College, and at several stations northward.

PERTH AMBOY.

1830.0.	4° 10′.	H. S. Haines. Change in bearing of old line at South Amboy.
1885.5.	7° 43′.	G. H. Blakeley.

Monmouth County.

FREEHOLD.

1887.9.	7° 15′.	North side of town.

IMLAYSTOWN.

1765.8.	4° 45′.	John Lawrence, at his house.

MORGANVILLE.

1887.9.	7° 35′.	At village and at Beacon Hill station. This hill of gravel, etc., has no effect whatever on the needle.

MOUNT MITCHELL—NAVESINK PARK.

1840.8.	5° 29′.	United States Coast Survey.
1844.0.	5° 39′.	United States Coast Survey.

RED BANK.

1887.9.	7° 23′.	South and east of town.

SANDY HOOK.

1686.0.	9° 00′.	Geo. Keith. Records of Proprietors of East Jersey.
1723.	7° 20′.	Lewis M. Evans, from map.
1842.7.	5° 32′.	United States Coast Survey.
1844.1.	5° 51′.	United States Coast Survey.
1855.6.	6° 11′.	United States Coast Survey.
1873.9.	7° 09′.	United States Coast Survey.
1879.5.	7° 32′.	United States Coast Survey.
1885.8.	7° 53′.	United States Coast Survey.

Date.	Declination West.	
		SEABRIGHT.
1884.7.	7° 12′.	G. H. Blakeley.
		SEA GIRT.
1884.9.	6° 59′.	G. H. Blake'ey.
1887.9.	7° 09′.	Extending 1½ miles inland.

Morris County.

		BARTLEY.
1887.8.	4° 08′.	On Schooley's mountain slope, three-quarters mile west of store.
1887.8.	9° 48′.	West side of the valley.
1887.8.	9° 03′.	East side of the valley.
1887.8.	8° 29′.	Top of ridge east of valley, road from Chester to Flanders.
		BUDD'S LAKE.
1880.0.	6° 42′.	One mile east, at top of mountain.
		BOONTON.
1887.9.	8° 05′.	Southeast of town in valley.
1887.9.	8° 27′.	Top of hill north of town.
		CHESTER.
1880.0.	7° 03′.	On Seward's hill, near cross-roads
1887.8.	7° 56′.	At the cross-roads. There seems to be a constant and rapid increase from here across the valley to the base of Schooley's mountain, amounting to nearly 2° in 3 miles, then a decrease in climbing the mountain.
		DOVER.
1887.8.	8° 58′.	At the town.
1887.8.	8° 20′.	On gravel terrace, 1 mile west.
		GILLETTE.
1887.9.	7° 53′.	One-half mile east of station.
1887.9.	7° 54′.	In Great swamp, one-half mile north of Long hill.
1887.9.	9° 34′.	Crest of Long hill, 1 mile northeast of Gillette railroad station.
		HANOVER.
1887.9.	8° 01′.	Average of 4 stations east and west of river.
		LAKE HOPATCONG.
1884.8.	8° 26′.	Bertrand island. G. H. Blakeley.
1884.8.	8° 15′.	Shippenport. G. H. Blakeley.
1887.8.	7° 49′.	Across head of lake south and west of Hurdtown.
1887.8.	8° 34′.	Head of Henderson cove, east foot of mountain.

Date.	Declination West.	
		MORRISTOWN.
1887.9.	8° 12′.	On mountain just west of borough limits.
1887.9.	9° 00′.	On drift at eastern borough limits, north of the Whippany.
1887.9.	8° 33′.	South of Horse hill.
		NEWFOUNDLAND.
1887.8.	7° 57′.	Crest of Green Pond mountain, 1 mile southwest.
1887.8.	7° 31′.	West base of Green Pond mountain.
1887.8.	7° 58′.	At Oak Ridge village.
1887.8.	9° 41′.	On mountain 1 mile south of Holland school-house.
		Change in bearings of lines surveyed about 1800 from 4° to 4½°. Horace Chamberlain.
		POMPTON.
1887.8.	10° 47′.	Top of trap ridge southeast of steel works.
1887.8.	9° 16′.	Village and 2 miles west in mountain south of Bloomingdale. Local attraction amounting to 20′, but no marked difference between mountain and valley.
		SCHOOLEY'S MOUNTAIN.
1887.8.	6° 25′.	One mile northeast of the mineral spring

Ocean County.

		BARNEGAT LIGHT.
1860.6.	5° 24′.	United States Coast Survey, Report of 1881.
1880.	6° 57′.	A. P. Irons.
1885.	7° 18′.	Schott's computation. United States Coast Survey Report, 1881.
		BARNEGAT VILLAGE.
1887.9.	6° 52′.	At village.
		FORKED RIVER.
1876.5.	6° 03′.	Moore. See United States Coast Survey Report, 1882.
1885.0.	6° 47′.	Schott's computation, Report, 1882.
		HARVEY CEDARS—LONG BEACH.
1860.6.	5° 18′.	United States Coast Survey Report, 1881.
1885.0.	7° 13′.	Schott's computation. United States Coast Survey Report, 1881.
		NEW EGYPT.
1887.9.	6° 56′.	North of village.

Date.	Declination West.	
		SEASIDE PARK.
1880.	7° 14′.	A. P. Irons, at Capt. J. Reed's house, south of village.
1887.9.	6° 56′.	At the village.
		WEST CREEK.
1745.	5° 25′.	Dennis. John Lawrence's notes. NOTE.—The true bearing of Lawrence's line from here to Collier's Mills, 30 miles, is N. 14° 42′ W. Lawrence ran on a magnetic course of N. 9° 19′ W., which shows a declination amounting to 5° 23′, and verifies the above observation conclusively. C. C. V.
		WHITINGS.
1887.9.	7° 09′.	About the village.

Passaic County.

Date.	Declination West.	
		BEARFORT MOUNTAIN.
1882.6.	8° 00′.	At United States Coast Survey station. Topographic Survey.
		GREENWOOD LAKE.
1887.8.	7° 40′.	At extreme south end of lake.
1887.8.	8° 03′.	Foot of Bearfort mountain. Warwick turnpike.
1887.8.	8° 34′.	Central ridge of Bearfort, just south of turnpike. A gradual increase going west.
		HIGH MOUNTAIN.
1883.6.	9° 03′.	Trap ridge north of Paterson. A. A. Titsworth.
		PATERSON.
1868.7.	6° 37′.	A. A. Fonda; reported by J. T. Hilton, C.E.
1869.1.	6° 37′.	Theo. Ryerson; reported by J. T. Hilton, C.E.
1887.8.	7° 51′.	North of Hawthorne station.
1887.8.	8° 06′.	As Fairlawn station.
		POMPTON.
1887.8.	9° 16′.	In valley at village.
		STATE LINE.
1874.6.	7° 14′.	At Longhouse creek.
1874.6.	6° 02′.	On Bearfort mountain.

Salem County.

Date.	Declination West.	
		CHURCH'S LANDING.
1846.4.	5° 49′ (?).	United States Coast Survey Report, 1881.
1885.0.	8° 32′ (?).	United States Coast Survey Report, 1882, Schott's computation.
		DELAWARE CITY, DEL.
1842.5.	3° 30′.	Barnett; Philadelphia, Trans. Roy. Soc., 1874.
1846.5.	3° 17′.	At Fort Delaware; United States Coast Survey Report, 1881.
1885.0.	5° 48′.	United States Coast Survey Report, 1882; Schott's computation for Fort Delaware.
		SALEM.
1887.8.	5° 42′.	North side of town.
		WILMINGTON, DEL.
1846.4.	2° 31′.	United States Coast Survey Report, 1881.
1875.5.	3° 44′.	United States Coast Survey Report, 1881.
1885.	4° 25′.	United States Coast Survey Report, 1882, Schott's computation.

Somerset County.

		BLAWENBURGH.
1887.9.	7° 36′.	In vicinity to beyond Skillman's.
		MIDDLEBUSH.
1884.9.	7° 13′.	G. H. Blakeley.
		SOMERVILLE.
		Observations reported by Joshua Doughty, Jr.
1864. (?).	5° 30′.	C. W. Van Nuys, observer.
1864.9.	6° 00′.	W. W. Drake, observer.
1865.3.	6° 15′.	Ab'm Stryker, observer.
1865.4.	5° 40′.	H. Cook, observer.
1865.6.	5° 49′.	Isaac P. Lindley, observer.
1865.9.	5° 55′.	Jacob Wyckoff, observer.
1865.9.	5° 50′.	Peter N. Van Nuys, observer
1866 5.	6° 15′.	D. Annin, observer.
1867.3.	6° 00′.	S. Gano, observer.
1867.5.	5° 50′.	Jacob Wyckoff, observer.
1867.8.	6° 00′.	S. Gano, observer.
1867.9.	5° 50′.	Peter N. Van Nuys, observer.
1868.3.	5° 58′.	S. Gano, observer.
1869.3.	6° 00′.	Joseph Thompson, observer.
1869.5.	6° 00′.	Joshua Doughty, Jr., observer.
1870.1.	6° 00′.	Joshua Doughty, Jr., observer.

Date.	Declination West.	
1873.4.	6° 27′.	N. McConaughy, observer.
1887.8.	7° 19′.	From 1 to 3 miles north of town.
		From the above the following series has been deduced:
1864.	5° 47′.	
1865.	5° 50′.	
1866.	5° 53′.	
1867.	5° 55′.	
1868.	5° 58′.	
1869.	6° 00′.	
1870.	6° 03′.	
1875.	6° 25′.	
1880.	6° 46′.	
1887.	7° 19′.	
1887.9.	7° 15′.	Foot of First mountain, north of town.
1887.9.	6° 42′.	Crest of mountain above. A value of 5° 56′ observed on face of mountain.
1887.9.	8° 32′.	In Washington Valley, 1 mile west of Martinsville. A value of 5° 31′ observed on north slope of First mountain.
1887.9.	7° 05′.	On crest of Second mountain, southwest of Mt. Horeb church.
1887.9.	7° 35′.	Just north of Mt. Horeb church. An apparent tendency of both trap ridges to repel the needle.

Sussex County.

ANDOVER.

1881.7.	6° 25′.	Hill just west of village. Topographic Survey. Mr. A. H. Konkle says that lines in Sussex and northern Warren counties run between 1790 and 1815 require a correction of from 4° 15′ to 4° 20′.

CARPENTER'S POINT.

1873.6.	7° 05′.	United States Coast Survey, at Tri-State rock.
1874.6.	7° 01′.	Prof. E. A. Bowser, at same place.
1884.8.	7° 51′.	Topographic Survey.
1887.8.	7° 50′.	At Tri-State rock and on east side of river.
1839.1.	4° 40′.	Two and a half miles south of here a line bore in 1839.1, N. 44° 30′ W., and in 1887.8, N. 41° 35′ W. Another line bore in 1839.1, S. 45° 30′ W., and in 1887.8, S. 48° 50′ W.

CULVER'S GAP.

1887.8.	7° 19′.	On turnpike, one-half mile west.
1887.8.	7° 29′.	Crest of mountain, south of gap.
1887.8.	7° 26′.	Summit of turnpike, 1 mile east of mountain.

Date.	Declination West.	
		DECKERTOWN.
1887.8.	7° 29′.	Irregular variations of 10′ within a mile. This is the value at three stations within a radius of half a mile of the center of the village.
		DINGMAN'S, PA.
1884.8.	6° 13′.	Topographic Survey.
		FRANKLIN FURNACE.
1887.8.	6° 36′ to 7° 47′.	Brow of mountain near Two Bridges.
1887.8.	7° 38′.	At village. Local attraction amounting to 1 degree observed.
		HAMBURG.
1882.8.	7° 04′.	One mile south of village, west side of Wallkill. Topographic Survey.
		HIGH POINT.
1887.8.	7° 50′.	Top and west slope of mountain.
		LAYTON.
1887.8.	7° 11′.	On Pompey ridge, east of its crest line.
1887.8.	7° 25′.	In valley at village, 1 mile east of above.
		LIBERTY CORNER, N. Y.
1874.6.	6° 45′.	Prof. E. A. Bowser. Boundary Survey.
		MILFORD, PA., AND MONTAGUE, N. J.
1884.8.	6° 56′.	Topographic Survey.
1887.8.	7° 06′.	Near the bridge, both sides of the river.
1887.8.	7° 21′.	At the "Brick House," Montague.
		MONROE CORNER.
1887.8.	7° 03′.	Just east of cross-roads.
		MOUNT SALEM.
1887.8.	7° 39′.	From 1 mile southwest of the village westward to the foot of Kittatinny mountain a slight increase is observed.
		NEAR WAWAYANDA MINES.
1874.6.	5° 09′.	Prof. E. A. Bowser. Boundary Survey.

Date.	Declination West.	
		NEWTON.
1881.8.	7° 01′.	A. H. Konkle, observer.
1883.4.	7° 02′.	A. H. Konkle, observer.
1884.9.	7° 05′.	A. H. Konkle, observer.
1885.4.	7° 11′.	A. H. Konkle, observer.
1886.0.	7° 08′.	A. H. Konkle, observer.
1886.3.	7° 08′.	A. H. Konkle, observer.
1887.0.	7° 17′.	A. H. Konkle, observer.
1887.4.	7° 17′.	A. H. Konkle, observer.
1887.9.	7° 17′.	A. H. Konkle, observer.
1887.8.	7° 21′.	Just south of village.
		UNIONVILLE, N. Y.
1874.6.	6° 03′.	Prof. E. A. Bowser. Boundary Survey.
		VERNON
1887.8.	2° 52′.	Brow of Wawayanda mountain, above village. Local attraction.
1887.8.	6° 15′.	Between village and railroad.
1887.8.	6° 41′.	West side of valley, one-quarter mile from meadow.
1887.8.	7° 08′.	Eastern foot of Pochuck mountain.
1887.8.	9° 08′.	Summit of Pochuck mountain, east of head of Decker pond. Both mountains seem to attract the needle here. The value, 6° 41′, is probably least influenced by this attraction.
		WARWICK MOUNTAIN.
1874.6.	3° 12′.	Prof. E. A. Bowser. Boundary Survey.

Union County.

		PLAINFIELD.
1887.9.	7° 40′.	South and west of town.
1887.9.	8° 18′.	Crest of First mountain, south of Stony Brook gap.
1887.9.	7° 42′.	Crest of Second mountain, road to Union village. Local attraction of 1° 40′ observed. The only effect of the trap ridges here is apparently local and irregular.

Warren County.

		ALLAMUCHY.
1887.8.	9° 00′.	On slope of mountain, road to Waterloo
1887.8.	8° 18′.	At west side of village.
1887.8.	7° 45′.	In valley, 2 miles northwest. There appears to be a steady increase going toward the mountain.
		BELVIDERE.
1887.8.	5° 32′.	There is a steady decrease going southeast, which amounts to 50′ at a point on the mountain 1 mile east of Oxford church.

Date.	Declination West.	
		BETHLEHEM, PA., SCHOTT'S TABLES.
1757.	6° 30′.	R. W. Walker, from bearings of old lines.
1784.	2° 53′.	Reference as above.
1799.	1° 52′.	Reference as above.
1841.5.	3° 26′.	Prof. A. D. Bache, at Easton, Pa.
1851.	3° 50′.	R. W. Walker, from bearings of old lines.
1874.5.	5° 20′.	Dr. T. C. Hilgard, near Lehigh University.
1878.2.	5° 37′.	R. W. Walker, from bearings of old lines
1881.2.	5° 52′.	Prof. C. L. Doolittle, Lehigh University.
1882.7.	6° 05′.	R. W. Walker, deduced from 80 observations by students.
1884.0.	6° 06′.	R. W. Walker.
		BLAIRSTOWN.
1887.8.	7° 25′.	Average of both sides of valley of the Paulin's Kill.
		EASTON, PA.
1841.6	3° 38′.	United States Coast Survey, Report of 1882.
1885.0.	6° 37′.	Schott's computation, Report of 1882.
		HACKETTSTOWN.
1887.8.	6° 25′.	Top of Schooley's mountain, 1 mile northeast of the mineral spring. Local attraction amounting to 3¼ degrees observed. Declination equals 3° 08′ at brow of mountain west of this point.
1887.8.	6° 50′.	On knoll south of village. West of the limestone quarries 8° 27′ was observed.
1887.8.	7° 02′.	Top of mountain just west of village.
		HARDWICK TOWNSHIP.
1866.1.	6° 03′.	Observed by A. H. Konkle at a point 2⅝ miles northwest of Marksboro, and 3 miles northeast of Blairstown.
1868.2.	6° 10′.	
1870.1.	6° 18′.	
1881.8.	6° 58′.	
1886.3.	7° 11′.	
		JENNY JUMP MOUNTAIN.
1881.8.	4° 45′.	Near south end of mountain on crest.
		PHILLIPSBURG.
1887.8.	6° 10′.	At several stations north and east.
		WARRENVILLE.
1881.7.	6° 00′.	Hill just west of village.
		WATER GAP.
1887.8.	6° 36′.	At Water Gap House, Pa.
1887.8.	7° 05′.	At Portland, Pa.
		There is a uniform increase in passing down the river through the Water Gap from Water Gap railroad station to Portland.

Magnetic Dips and Intensities.

In Appendix No. 6, United States Coast and Geodetic Survey Report for 1885, will be found a complete collection and discussion of magnetic dips and intensities for the United States, by Chas. A. Schott, Assistant. Although this paper has to do principally with declination and its distribution, the collection of dips for New Jersey may prove useful to some in this connection.

Magnetic Dips and Horizontal and Total Magnetic Intensities in New Jersey.

STATION.	Year.	Dip.	Horizontal force.	Total force.	Reduced to 1885. Dip.	Reduced to 1885. Horizontal force.	Reduced to 1885. Total force.
Cape May Light-house	1846.5	71° 25′.8	4.255	13.36			
Cape May Light-house	1855.6	71° 34′.4	4.182	13.23	70°.99	4.304	13.21
Cape May Light-house	1874.5	71° 28′.5	4.288	13.48			
Town Bank	1846.5	71° 23′.6	4.269	13.38	70°.88	4.334	13.23
Egg Island Light-house	1846.5	71° 45′.1	4.206	13.43	71°.24	4.271	13.28
Port Norris	1846.5	71° 39′.6	4.211	13.38	71°.15	4.276	13.24
Atlantic City	1860.6	71° 47′.0	4.205	13.45	71°.18	4.288	13.29
Pine Mount (near Greenwich)	1846.5	71° 41′.4	4.237	13.49	71°.18	4.296	13.32
Long Beach	1860.6	71° 58′.5	4.156	13.48	71°.37	4.240	13.27
Tuckerton	1846.9	72° 12′.3	4.068	13.30	71°.69	4.129	13.14
Church Landing, Salem county	1846.4	71° 22′.0	4.311	13.49	70°.86	4.377	13.35
Barnegat Light-house	1860.7	72° 05′.3	4.108	13.36	71°.49	4.191	13.20
Chew, near Mantua	1846.5	72° 14′.4	4.105	13.46	71°.73	4.171	13.31
White Hill	1846.4	72° 06′.2	4.147	13.50	71°.59	4.218	13.34
Trenton	1841.3	71° 59′.0	4.196	13.56	71°.46	4.242	13.34
Princeton College	1839.7	72° 47′.1	4.041	13.55			
Princeton, behind College	1842.8	72° 43′.5	4.010	13.504			
Princeton, near College	1843.5	72° 38′.3	4.222	....			
Princeton, near College	1844.0	72° 39′.5	....	....	72°.17	4.110	13.42
Princeton, near College	1844.4	72° 40′.2	4.016	13.48			
Princeton, Potts' woods	1844.4	72° 41′.4 72° 41′.2	4.017 3.999	13.50 13.44			
Princeton, on Rocky Hill (trap)	1844.4	72° 35′.0	4.049	13.58			
Mount Rose (trap)	1852.6	72° 42′.5	4.130	13.90	72°.16	4.211	13.75

Magnetic Dips and Horizontal and Total Magnetic Intensities in New Jersey—Continued.

STATION.	Year.	Dip.	Horizontal force.	Total force.	Reduced to 1885. Dip.	Reduced to 1885. Horizontal force.	Reduced to 1885. Total force.
Sandy Hook	1844.6	72° 37′.9	4.077	13.66	71°.93	4.081	13.16
Sandy Hook	1855.6	72° 52′.0	3.917	13.30			
Sandy Hook	1878.9	72° 29′.6	4.040	13.43			
Sandy Hook	1879.6	72° 08′.3	4.078	13.30			
New Brunswick	1844.4	72° 43′.2	4.008	13.50	72°.21	4.066	13.31
Snake Hill	1844.3	72° 45′.4	....	....	72°.25	....	....
Newark	1841.3	72° 48′.5	3.999	13.54	72°.31	4.037	13.29
Newark, Washington Place	1844.3	72° 50′.2	3.972	13.46			
Newark, on the neck	1844.3	72° 46′.3	3.986	13.46			
Newark	1846.4	72° 52′.2	3.964	13.46			
Fort Lee	1844.3	72° 41′.0	....	....	72°.17	....	....
Paterson	1844.3	72° 17′.0 to 75° 00′.0	....	....	....	....	....

Secular Change of Magnetic Declination.

Mr. Charles A. Schott gives, in Appendix No. 12, Report of United States Coast and Geodetic Survey for 1886, a collection of declinations and a discussion of the secular change for the United States, which leaves little to be desired for the use of the surveyor. This work has been largely drawn upon for the following material necessary to make the results of the Magnetic Survey as useful as possible to the New Jersey surveyor. Matter of local interest has been extracted and to it has been added the information derived from the Magnetic Survey.

Table of Decennial Values of the Magnetic Declination.

The values given below will be found useful when old lines have to be retraced. The amount of declination varies often two or three degrees within two miles or less, but the change of declination, from year to year, will be found to be practically the same over quite large areas. The values at New York, N. Y., Bethlehem, Hatborough and Philadelphia, Pa., were carefully computed by Mr. Chas. A. Schott, and are given in Appendix No. 12, Report of the United States Coast

and Geodetic Survey for 1886. The series for New Jersey county seats were obtained graphically by reducing all of the observations available in the vicinity to that locality, and constructing an average curve with due attention to curves for New York and Philadelphia.

Decennial Values of Magnetic Declination.

YEAR.	New York, N. Y.	Bethlehem, Pa.	Hatborough, Pa.	Philadelphia, Pa.	Cape Henlopen, Del.
1600	*5° 00′	....	....	....	*3° 00′
1610	6° 00′	....	....	....	4° 00′
1620	6° 30′	....	....	....	4° 30′
1630	7° 00′	....	....	....	5° 00′
1640	7° 30′	....	....	....	5° 30′
1650	8° 00′	....	....	....	6° 00′
1660	8° 30′	....	....	....	6° 30′
1670	8° 54′	....	....	....	6° 36′
1680	9° 06′	....	8° 18′	....	6° 30′
1690	9° 00′	....	8° 12′	....	6° 24′
1700	8° 42′	....	7° 54′	8° 12′	6° 00′
1710	8° 12′	....	7° 30′	7° 48′	5° 30′
1720	7° 42′	....	7° 00′	7° 24′	4° 54°
1730	7° 18′	....	6° 24′	6° 48′	4° 12′
1740	6° 42′	....	5° 42′	6° 12′	3° 30′
1750	6° 00′	6° 06′	4° 48′	5° 18′	2° 48′
1760	5° 18′	5° 18′	3° 54′	4° 24′	2° 12′
1770	4° 42′	4° 30′	3° 06′	3° 36′	1° 36′
1780	4° 24′	3° 42′	2° 24′	2° 48′	1° 12′
1790	4° 24′	3° 06′	2° 00′	2° 18′	0° 54′
1800	4° 18′	2° 36′	1° 48′	2° 06′	0° 48′
1810	4° 24′	2° 18′	2° 00′	2° 09′	0° 54′

* Results for the seventeenth century are very doubtful.

Decennial Values of Magnetic Declination—Continued.

YEAR.	New York, N. Y.	Bethlehem, Pa.	Hatborough, Pa.	Philadelphia, Pa.	Cape Henlopen, Del.
1820	4° 31′	2° 18′	2° 30′	2° 26′	1° 06′
1830	4° 55′	2° 30′	3° 00′	2° 55′	1° 30′
1840	5° 36′	2° 54′	3° 42′	3° 28′	2° 02′
1850	6° 21′	3° 27′	4° 21′	4° 04′	2° 39′
1860	6° 58′	4° 41′	5° 00′	4° 44′	3° 20′
1870	7° 28′	5° 00′	5° 42′	5° 26′	4° 02′
1880	7° 55′	5° 51′	6° 42′	6° 12′	4° 43′
1890	8° 24′	6° 40′	7° 36′	6° 58′	5° 20′
1895	8° 42′	7° 02′	7° 54′	7° 24′	5° 36′

Decennial Values at County Seats.

YEAR.	Newton.	Somerville.	New Brunswick.	Mount Holly.	Woodbury.
1800	3° 00′	2° 41′	3° 06′	2° 14′	1° 40′
1810	3° 03′	2° 44′	3° 08′	2° 17′	1° 43′
1820	3° 19′	3° 01′	3° 32′	2° 34′	2° 00′
1830	3° 48′	3° 20′	4° 12′	3° 03′	2° 29′
1840	4° 21′	4° 03′	4° 52′	3° 36′	3° 02′
1850	4° 57′	4° 39′	5° 18′	4° 12′	3° 38′
1860	5° 37′	5° 19′	5° 46′	4° 52′	4° 18′
1870	6° 18′	6° 01′	6° 30′	5° 34′	5° 00′
1880	6° 53′	6° 47′	7° 15′	6° 20′	5° 46′
1890	7° 26′	7° 33′	7° 40′	7° 06′	6° 32′
1895	7° 43′	7° 56′	7° 58′	7° 32′	6° 58′

For the other county seats the values may be found approximately as follows: Belvidere, 1° 49′ less than Newton; Bridgeton, 1° 10′ less than Philadelphia; Camden may be taken same as Philadelphia; Cape May Court House, 30′ less than Woodbury; Elizabeth, 28′ less than New York; Flemington, 5′ less than Somerville; Freehold, 29′ less than New Brunswick; Hackensack, 25′ less than New York; Jersey City, 18′ more than New York; Mays Landing, same as Woodbury; Morristown, 21′ more than New York; Mount Holly, see table; Newark, 28′ less than New York; New Brunswick, see table; Newton, see table; Paterson, 25′ less than New York; Salem, 20′ less than Woodbury; Somerville, see table; Toms River, 32′ more than Mount Holly; Trenton, 25′ more than Philadelphia.

Any other points may be obtained approximately by observing the difference between the recorded declinations as observed by the Topographic Survey in 1887 for the given station and for the nearest station given in the above list or tables.

Solar Diurnal Variation.

This is the only other important change in magnetic declination, beside the secular change above considered, which is regular enough in character to be taken into account in observations. It consists of a swing of the needle through the 24 hours, averaging 8′ at Philadelphia, and varying from $10\frac{1}{2}'$ in August to 6′ in November. It is generally so much within the limits of accuracy of ordinary surveyors' instruments, and disturbances too irregular to be allowed for, but greater in amount than the daily range, occur so frequently that it may as well be neglected in ordinary surveying. In all observations for magnetic declination, however, it should be taken into account, and as it is to be hoped that these may be more frequently made in the future, the following table is appended. It is taken from a more extended one in the United States Coast Survey Report for 1875, p. 263. The + quantities are to be added to all west declinations and the — quantities subtracted, to reduce them to the mean value for 24 hours.

Corrections for Solar Diurnal Variation at Philadelphia, Pa.

	7 A. M.	9 A. M.	11 A. M.	1 P. M.	3 P. M.	5 P. M.
January	+1′.2	+2′.5	+0′.3	−3′.4	−2′.5	−0′.9
February	+1′.9	+2′.5	+0′.2	−3′.0	−2′.4	−1′.2
March	+2′.9	+3′.4	+0′.6	−3′.9	−3′.2	−1′.6
April	+3′.5	+3′.4	+1′.1	−5′.1	−4′.3	−1′.8
May	+4′.7	+3′.2	+1′.9	−5′.1	−3′.9	−1′.2
June	+5′.0	+3′.8	+1′.7	−5′.0	−3′.8	−1′.6
July	+5′.4	+4′.0	+1′.5	−5′.3	−4′.5	−2′.0
August	+5′.7	+3′.7	+2′.9	−6′.3	−3′.8	−0′.9
September	+4′.5	+2′.8	+3′.2	−5′.5	−3′.0	−0′.8
October	+1′.7	+1′.9	+0′.8	−3′.2	−2′.2	−0′.3
November	+1′.7	+1′.5	+1′.1	−2′.8	−1′.9	−0′.6
December	+1′.0	+1′.6	+0′.3	−3′.0	−2′.3	−0′.6

The other periodic variations are the *annual*, amounting to 1½, minutes of arc, and the *lunar diurnal*, with a range of 27 seconds and two maxima and two minima in each lunar day.

Magnetic Disturbances and Storms.

These occur irregularly and are beyond the power of prediction. They are an important source of error in compass surveys, as the following table shows. It gives the observed disturbances in a bi-hourly series at Philadelphia in the years 1840 to 1845, furnishing a good indication of the relative frequency and magnitude of such disturbances. It is taken from Appendix No. 12, United States Coast and Geodetic Survey Report for 1886:

Deviations from Normal Direction.	Number of Disturbances.
3′.6 to 10′.8	2,189
10′.8 to 18′.1	147
18′.1 to 25′.3	18
25′.3 to 32′.6	3
Beyond.	0

Mr. Wm. J. Young, of Philadelphia, observed with a fourteen-inch needle a variation of 1° 10′ in position within one hour during an active aurora. January 3d, 1870, Mr. William Haines observed during a time of brilliant auroral display a change of 2° 10′ in the position of the needle between 5:30 and 7:25 A. M., at Clarksboro, N. J.*

Imperfections of Needle Instruments.

The disturbances noted above and the irregular distribution of declination introduce unavoidable and unforeseen elements of error with even the most perfect instruments; but it may be well to call attention here to the differences which exist between different needle instruments, and even well-constructed ones. In faulty instruments, malformation or dullness of pivot, or bad centering, causes errors. In good instruments they may arise from loss of polarity of the needle, or from lack of coincidence between the line joining the two points of the needle and its magnetic axis. Even when this has been guarded against in construction, the position of the magnetic axis may afterward change. A gentleman largely engaged in the manufacture and repair of surveying instruments has, at my request, made some trials, and sent me the results. From three new compasses of the best construction he obtained the following:

	First Trial.	Second Trial.
No. 1	15° 8′	15° 8′
No. 2	15° 12′	15° 14′
No. 3	15° 15′	15° 16′†

An analysis of 181 readings taken by the members of the West Jersey Association on their various instruments, shows that 122 of the readings are within 5′ of the adopted means which have been assumed to be correct. The remaining 59 readings are out more than 5′ and range up to 21′, and one reading is out 34′. Variations of 10′ are observed in the readings of a single instrument in several cases, and a departure from the mean, amounting to 5′, is not necessarily an indication of instrumental defects.

An examination of several instruments, made as a preliminary to the magnetic survey of New Jersey, showed in one case an error of

* Proceedings of the Surveyors' Association of West New Jersey, p. 61.

† Report to the Board of Freeholders of Middlesex county upon true meridian lines. Geo. H. Cook, 1864.

$1\frac{1}{4}°$ in a needle with a tapering north point and thick south end, the pivot being at a point about one-third of the way from the south to the north end. In another case a symmetrically-tapered, nicely-balanced needle, four inches in length, showed an error of 25′. Another six-inch needle showed an error of 10′. These are rather exceptional cases, but as they are instruments of different makers, in good order, and carefully compared, they point out the danger of error from this source.

In conclusion, it may be said that the data given above are sufficient to enable compass surveys to be made with all the accuracy of which the method is capable. While the compass must still be used in retracing old lines, the teaching of the irregularities of magnetic declination shown by the isogonic chart and list of declinations, of the notes on magnetic disturbances, and those on instrumental defects, is clearly that no new surveys should be recorded by reference to the magnetic needle alone. The time has come when its use for this purpose should be discontinued throughout the greater part of the State.

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NOTE.—Pages of the Appendix are marked A.